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Testing the Music Reading Skills of 10- to 14-Year-Old Students

PhD dissertation

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Contents

’Music is the manifestation of the human spirit, similar to a language. Its great men have conveyed to humanity things unutterable in any other language’

Zoltán Kodály

Introduction

The history of music reading instruction leads back to about 1000 years ago, when Guido of Arezzo invented a system of music notation and syllable names that spread throughrout the world and became integrated into a variety of educational systems. New methods of learning to read and notate music were developed over the centuries, but the target of music instruction remained the same; music education in schools helps students to enhance their sensibilities to art while developing their musical skills.

Improving music reading skills forms a central part of music education. It includes instrumental, vocal and solfege trainings. Music education in Hungary is based on the well-known Kodály concept. Kodály’s pedagogy emphasizes developing music literacy through the innate music of the culture, beginning with folk songs that he rated alongside the works of classical composers. It was almost 70 years ago in 1947, when Kodály wrote about his idea in his article entitled *The 100 Year Plan* in a music teachers' journal: ’…it may well be hoped that by the time we reach 2000, every child who has attended a primary school will be able to read music fluently. This, however, will only be an external sign of what will surely have developed by then and will rightly bear the name of Hungarian culture’ (Kodály, 1974, p. 209). In order to enhance students’ reading skills, Zoltán Kodály composed a series of music reading materials which is currently used in all levels of music education.

Although a great number of music students learn music reading, only a few studies aim to examine its teaching and there are no comprehensive examinations of this issue. It was based on the research carried out by József Nagy, Istvánné Erős, Katalin Fodor, István Pethő, which formed the basis of which the model of basic musical skills was defined at the beginning of the 1990s. They explored the musical skills of children aged 10, 14 and 16, and of university students, including music listening abilities, communication, music reading and writing. The longitudinal study conducted by Turmezeyné, Máth and Balogh (2005) was a milestone in the field of research of music perception, singing, music reading and writing skills among 7-10 year-old children. Technology-based assessment is a rapidly developing area, which can be extended to musical skills and provides new possibilities for diagnostic testing. The research of

Asztalos and Csapó (2015) was the first attempt in developing an online test to examine music perception skills and developmental trends among 7- to 12-year-old students. However, we still lack data on the music reading skills of students between the ages of 10 and -14. Neither are there tests to assess their music reading skills.

The international scholarly literature explores music reading skills with eye tracking technology. Most eye-movement studies focus on instrumentalists, e.g. pianists, violin or guitar players. They primarily aim to compare the eye-movement patterns of skilled and unskilled performers, generally adults. However, it is of crucial importance to compile proper music reading material. My literature review has indicated that the readability of the materials has not yet been examined.

The major aims of the present doctoral dissertation are (1) to analyze students' music reading skills on the basis of Zoltán Kodály's philosophy of music education and (2) to develop and test technology-based instruments and procedures to assess music reading skills. To my knowledge, no national or international empirical measurement or analysis procedures on the level of the music reading skills of 10-14 year-old children have been published.

In the first chapter of my dissertation, I provide an overview of the research on the cognitive aspects of music reading based on the comparison of the results of studies on language and music, as well as recent developments in neurocognitive research. In the second part of this chapter 1 examine research on testing musical abilities in Hungary and abroad and also introduce theories and studies that summarize musical skills. I discuss the process of singing, because solo and choir singing, i.e. *vocalism*, is a fundamental principle of the Kodály concept. An increasing body of research on singing and its transfer effects has emerged in recent decades. However, musical activities have their transfer effects only if they are not perceived as torture, but as pleasure for the individuals (L. Nagy, 2004, cited in Dohány, 2009). Upper grade students' motivation and attitudes towards singing have not been examined yet. Therefore, I intend to explore them in my research.

In the second chapter of the dissertation, I focus on music reading skills. A large body of research has been conducted on reading, while reading music has received much less attention. According to Hodges (2011), music reading is a process of converting special visual symbols – music notation – into sounds. The sounds may be silent, conceived internally, or they may be produced externally through the human voice, with musical instruments, or from a digital source. However, the concept cannot be narrowed down to this simple definition. Furthermore, to my knowledge there are no comprehensive theories of music reading. In this chapter, I also summarize the results of eye-tracking research. Eye-tracking is used in several areas of educational research, primarily in studies on reading. Fewer studies examine singers, while none of them explore a specific music method. In my research I am dealing with the latest ones based on the Kodály concept.

In chapter 3, I focus on the Kodály concept. In the school context, music education begins at the pre-primary level and continues until the end of lower secondary education, when pupils are between 14-16 years of age in the majority of the countries. Music literacy skills are then presumed to be firmly established. To establish this skill, Kodály suggested adopting relative solmization on the basis of John Curwen's Tonic Sol-fa system of music education in England. Testing the reading of sol-fa and hand signs has not yet been examined. Kodály's music reading exercises serve as a fundamental basis of the general and specialized music education. However, the readability of Kodály's reading exercises has also not yet been examined. In the following chapters, the aspects of music curricula are also analyzed.

In chapter 4, I concentrate on the hypotheses, methods and instruments of my empirical research. In the next chapter, I am going to analyze the results of music reading tests conducted with eye-tracking technology and analyze the mean average of the achievements by gender and grade. As I conducted my studies in Hungarian and Luxembourger primary and specialized music schools, I also compare the effects of the different music teaching methods.

In chapter 6, the online diagnostic music reading assessments will be introduced. The local pilot tests are followed by cross-sectional studies on a national sample. The purpose of my cross-sectional study conducted on a national sample is to measure the success rate and evaluate of music reading skills acquired from mainstream and specialized music education. My assessment was carried out using computer-based musical assessment tools. These are efficient and easy-to administer, providing a highly motivating environment for students and opening new possibilities in the field of technology-based transfer research. Computer-based data collection enhances the objectivity and validity of the measurement and evaluation with a facilitating usage (Csapó et al., 2012). In this chapter I also summarize the results about the level of students' music reading skills in the different school types.

Some parts of the present study have been published earlier. In chapter 2, the section on the use of digital tools in music education appeared as part of a volume on possible innovations in music education (Buzás, 2014). An article on the transfer effects of group singing was published in the volume of the 14th National Conference on Education (Buzás & Maródi, 2015). Eye-tracking studies in connection with music reading with Hungarian and foreign music students were published in a book on Music Education at the University of Luxembourg (Buzás, 2016). Also, conference lectures were presented on the development of online music reading tests. The results of the online test of music reading skills of 10-14-year-old students were presented at the 1st Conference on Information Technology in Education (Buzás & Maródi, 2016). In addition, the present dissertation contains the results of research presented at the 10th Conference on Educational Assessment (Buzás & Steklács, 2014), the National Conference of Education (Buzás, 2012) and the 16th JURE Conference organized by the European Association on Research on Learning and Instruction.

1. Theoretical background

Chapter 1 focuses on the skills and abilities that are theoretically relevant to music reading. I review the latest research on music perception and processing in the nervous system. The results of cognitive neuroscience can contribute to the more precise interpretation of my research objectives. Then I concentrate on some possible musical universals, e.g. musical scales and intervals that form the part of my music reading test. The subsequent parts of the chapter provide a detailed presentation of different theories and cognitive models that have been proposed to explain the complexity of musical skills. In addition, musical ability and achievement tests are introduced. Besides music perception skills, i.e. melody, harmony, rhythm, dinamics and timbre, further musical skills, e.g. audiation or improvisation, are also analyzed. Furthermore, I would like to focus on the process of singing and its transfer effects, as it is a fundamental principle of the Kodály concept. Lastly, I am going to discuss some relevant studies that explore the relationship between spatial and musical skills.

1.1. Cognitive perspective of music reading acquisition

Music exists across the human history and forms an integral part of the cultural heritage of human societies. Music-making is one of the most ancient human characteristics, and human musical ability has a long evolutionary history (Morley, 2002). Music and language skills enabled the emergence of modern human social and individual cognitive flexibility; both music and language can be regarded as subcomponents of the human communicative toolkit (Cross, 1999). Ethnographic evidence suggests that musical behavior has a tradition of at least sixty-thousand years (Cross & Morley, 2008). It is likely that before the Homo Sapiens, the Neanderthals were showing artistic creativity. The oldest archaeological evidence for musical instruments is estimated at about 43,000 up to 82,000 years old, from the Neanderthal age. In a Slovakian cave, the *Neanderthal Flute* was discovered, made of a bear's femur bone with four regular but unequal spaced drill holes. The different distances of the holes on this ancient recorder allow to sound unequal intervals of a diatonic scale which can be found from several musical cultures (Acsády, 2003). Maybe this is the earliest form of a musical scale from ancient times. The holes on this recorder also indicate the tuning of a wind instrument. Ethnomusicology treats the musical scale as an object of cognitive theory. Any kind of measurement can only be interpreted once it is integrated into its own cultural context. The musical scale is constituted by intervals that are culturally relevant in music processing, as fundamental principles of auditory pattern perception.

Humans have been using sound to enhance their communication, and *song* may have been the earliest form of speech (Ulbaek, 1998). Darwin (1871) argues that musical capacity developed from the tones used in passionate speech and he claims that music contributed to the development of language. Darwin connects music to strong emotions because many animals make noises to attract mates, express emotions and communicate with others.

Music is present in several kinds of gatherings from the ancient times; through dancing, rituals and ceremonies, music strengthens interpersonal bonds and identification with one's group. Dissanayke (2000) suggests that songs developed from the most primary bond of social cohesion, i.e. between mothers and infants. The mother's vocal behavior of singing and expressive speech was generating emotional communion through a process called emotional contagion (Hatfield, Cacioppo & Rapson, 1994). Therefore, music processing is not the result of a recent development, as music was already important in prehistoric times.

From a neuropsychological point of view, however, music and speech perception and processing are different activities. Also, localizing music perception in the brain is more difficult than that of speech (Papp, 2004). Altenmüller and Gruhn's (2002) findings in functional neuroanatomy suggest that music perception involves three connected areas: 1) the primary auditory area, 2) the secondary auditory areas and 3) the auditory association areas situated in the two temporal lobes of the brain. The primary auditory area is mainly involved in basic auditory processing such as pitch and loudness perception, perception of time structures, and spectral decomposition of sounds. The secondary auditory area is around the primary area in a belt-like formation, where more complex auditory patterns such as timbre are processed. In the auditory association areas, *auditory gestalt* perception takes place. *Auditory gestalt* can be understood as pitch-time patterns like melodies and words.

Gruhn (2003) found that time structures are largely processed in the left temporal lobe, whereas pitch structures are processed primarily through the networks in the right temporal lobe. On the basis of Hámori's study (2002), Hegedűsné (2015) summarizes brain processes during musical and connected activities (Table 1).

Table 1 Musical and other related activities in the two hemispheres of the brain (Hegedűsné, 2015, p. 13)

Left hemisphere	*Right hemisphere*
language functions; grammar, vocabulary, and literal meaning, speech comprehension and analysis temporal perception, sense of rhythm right hand movement (that is better in marking tempo) logical thinking, reasoning	the majority of musical skills: tonal, pitch and harmony hearing, absolute hearing visual, spatial perception left hand movement abstract thinking, creativity, understanding of musical communication, processing emotions, sensitivity to nonverbal effects, music perception, enjoyment of music, association, memorizing melodies, ability to recall music

The brain has the potential to reorganize its neural networks. As a result of the effects of musical perception, neural structures are rearranged (Bever & Chiarello, 1974). These activities involve much larger brain region than the simpler verbal activities and obliterate the boundaries between the classical dominant or non-dominant hemispheres (Ojemann & Creutzfeld, 1987).

Music instruction for children at an early age activate abundant and efficient connections, even resulting in the increased size of the activated brain areas (Flohr & Hodges, 2002). Altenmuller and Gruhn's (1997) results suggest that musical expertise influences auditory brain activation patterns. They claim that changes in these activation patterns depend on the teaching strategies applied. So the brain structures involved in music processing reflect the personal experiences accumulated over time.

Turning to music performance, which includes music reading as well, it can be said that it is one of the most demanding and multiple tasks for the central nervous system. It comprises the precise execution of very fast and complex physical movements under constant auditory feedback and also the involvement of emotional reactions (Wan & Shlaugh, 2010).

1.2. Sensitive periods of music training

The theory of *critical* or *sensitive period* originates from language acquisition from Lenneberg (1976). According to him, some biological events related to language and hemispheric specialization can occur only at an early sensitive period. If language acquisition takes place at a specified and predetermined age, it can be easier and more effortless. After the critical period, i.e. at about the age of 10-12, it is more difficult to acquire a language. According to Lenneberg, the closure is based on the stabilization of the cerebral hemispheres functional asymmetry, which would be in conjunction with the start of puberty. Instead of one single critical period, Pléh (1998) assumes that different ages exist for the different sub-systems of language acquisition as particularly sensitive periods.

On the other hand, it is more difficult to analyze the critical periods for musical development because of the complex combination of general and musical-system-specific learning (Trainor, 2005). In children with normal hearing, auditory cortex shows an extended developmental period. This is different from the visual system, where the adult level is reached in the first few months of life (Kinney et al., 1988, cited in Penhune, 2011). Between the ages of 1-5, there is a massive growth in the number of synapses within the auditory cortex. These connections are stimulated both by direct sensory input and by feedback from other brain areas (Moore & Linthicum, cited in Penhune, 2011). The further period of development is from ages 5 to 10, when there may be multiple sensitive periods for musical training. Certain musical skills are inherited, and some are acquired after birth. As students are born with different musical talents, skills or biological predisposition into different environments, they develop their innate capacities in different ways. Correlations were found between the size of the musicians' neurophysiological responses and the age of onset of music lessons, suggesting that a sensitive period for attaining the brain changes associated with musical expertise may end around ten years of age (Trainor, 2005).

1.3. Some possible cross-cultural universals in music

As music and speech can be found in all known human cultures, both are universals (Csépe, 2007). Modern auditory theory suggests that the mechanisms for pitch perception also fits as a universal in human auditory perception, and has implications for the design of musical instruments (Harwood, 1976). The kinds of sounds and range of pitches that humans can hear is also universal and there is an overlap of coding between 100-1000 Hz, which is precisely the frequency range over which human hearing is most accurate.

According to Meyer, (1998), all humans have the ability to recognize the differences between different tones, timbres, instruments or voices, to describe the particular characteristics of various sounds and to perceive loudness and softness similarly, so that tone, timbre and dynamic hearing are universal factors. They are manifold and can include hierarchical metrical organization, the use of scales consisting of a certain number of notes per octave (even the particular intervals between scale notes differ across systems), and the dimension of consonance/dissonance in the process of musical tension and relaxation. The basis of the possible cross-cultural musical universals could be that humans share some basic physical characteristics. Therefore, there is a relationship between musical tempo and heartbeat or the speed of breathing, walking, or other bodily movement and a relationship between the musical phrase lengths and the capacity of the human lung. Musical phrases tend to last ten or less seconds and usually contain eight bars.

According to Dowling and Harwood (1986), the majority of cultures use steady musical scales that share certain general properties; discrete pitch levels, octave equivalence, a moderate number (usually 5–7) of pitches within the octave, and a tonal hierarchy in which certain pitches function as stable points of melodic resolution and others as contrasting unstable points. Trehub (2003) outlines that pitches are usually separated unequally in the scale, by a tone, or by a semitone and it appears that the human perceptual system is set up to better process unequal scale steps than equal ones (Sloboda, 1984). The perfect fifth interval (Schellenberg & Trehub, 1994), and the perception of consonance and dissonance harmonies may be the outcome of the universal attributes of the human auditory system (Tramo et al., 2003) and an aversive emotional response to dissonance is also innate (Trehub, 2003; Gosselin et al., 2006).

Lomax (1977) explored musical universals in connection with songs. He analyzed the musical performance of 4000 songs from 148 geographically and culturally different regions of the world. He reduced them to two basic origins in connection with their structures. The first, Artic hunters and fishers, is characterized by male-dominated solos and unison singing, and by irregular rhythms. The second, African gatherers, in contrast, is feminized, poly-voiced, regular in rhythm, repetitious and brief. Across cultures infant direct songs, lullabies and play-songs appear to be a human universal with shared features, such as gentle dynamics, gradual pitch contours, contour simplicity, repetitive motifs, and a predominance of descending intervals (Trehub et al., 1993). Empirical researches with adult listeners have confirmed that one of the most distinctive features of an unfamiliar melody is its melodic contour, suggesting that sensitivity to melodic contour is also a musical universal.

Trehub (2015) found some musical universals that exist across nine geographic regions. She relates music to roles in facilitating group coordination and cohesion, as represented by the universal tendency to sing, play percussion instruments, and to dance to simple, repetitive music in groups.

1.4. Models of musical skills

During the 20th century, researchers developed different models to categorize musical skills. Some of them still have a significant influence on music psychology. One of the most well-known models of musical skills was offered by Seashore in 1919. He grouped 25 skills in five categories to create an overall system of musicality:

1) musical perception and sensitivity
2) musical activity
3) musical memory and imagery
4) musical sense
5) musical emotion

This model contains some extramusical skills, such as general intellectual and learning abilities. One of the most generally accepted definitions of the components of musical skills was given by Gembris (2002). According to him, musical skills comprise several factors, such as singing skills, music-specific cognitive processes, emotional and musical experience, motivation, music preferences, attitudes and interest.

Edwin Gordon's audiation theory is based on the relationship between music and language learning. He claims that language and speech, thought and music, performance and audiation have similar meanings. Király (2012) summarizes Gordon's communication-model (Table 2).

Table 2 Gordon's communication-model as adapted by Király (2012, p. 15)

LANGUAGE	*SPEECH*	*THOUGHT*
results of the need to communicate	how communication takes place	what is communicated
MUSIC	*PERFORMANCE*	*AUDIATION*

Gordon (1994) distinguishes eight types of audiation. The types of audiation are not hierarchical. Some of the types, however, serve as markers for others. 1) listening to familiar or unfamiliar music, 2) reading familiar or unfamiliar music, 3) writing familiar or unfamiliar music from dictation, 4) recalling and performing familiar music from memory, 5) recalling and writing familiar music from memory, 6) creating and improvising unfamiliar music, 7) creating and improvising unfamiliar music while reading, 8) creating and improvising unfamiliar music while writing.

Gordon's skill-learning sequence begins with the aural/oral stage in which children encounter patterns in the context of music-listening activities, and they learn specific tonal and rhythm patterns by echoing the teacher. In order for children to understand music, they must build a vocabulary of tonal and rhythm patterns, comparable to a vocabulary of words in language. Basic reading skills first develop as teachers guide students to connect symbols with known patterns. Additional patterns are connected to notation, and the essential encoding that occurs during verbal-association activities facilitates the students' ability to progressively store an extensive vocabulary of symbol patterns in long-term memory. As a result, students can begin to sight-read series of patterns. Creativity, improvisation and theoretical understanding, therefore, serve as the highest levels of Gordon's learning sequence (Ester, 2010). Gordon's research indicates that children's musical potential is malleable until the age of nine, at which time it stabilizes; this achievement potential remains firm for the remainder of the child's life (Gordon, 2007).

1.5. Research on testing musical skills

Füller (1974) divided music tests into four basic standard musical test groups. We can distinguish musical ability or aptitude tests (Seashore, Drake, Gordon, Gaston, Bentley) and also achievement tests (Beach, Hutchinson, Allen, Knuth, Colwell, Wagner). Vocal and instrumental tests were constructed (Hildebrand, Mosher, Watkins-Farnum), and music preference tests were also developed (Hevner, Schoen, Kyme). In this section, I would like to concentrate on the first two types of test, because they are the ones which are relevant in my dissertation.

The first test of musical skill on musical talent was designed by Seashore in 1919. However, it was revised and published several times, e.g. *Measures of Musical Talent* (Seashore et al., 1960), where the norms are given for boys and girls between 10 and 22 years of age. The test contains six subtests; pitch discrimination, loudness discrimination, rhythm, sense of time, timbre discrimination and tonal memory. The Seashore test principally examines aural skills and the musical phenomena are presented without any musical context. This is one of the reasons why Teplov (1947) and Michel (1960) reject the method of testing since they miss the enculturation factors in connection with the tests. Kwalwasser-Dykema's test (1930), designed for students aged between 10-22, shares similarities with Seashore's; however, music notational exercises were added. Arnold Bentley developed his *Measures of Musical Abilities* (1966), which appeared on LP records and was used in many schools in the United Kingdom. There were some negative remarks about the test; for example, it was said to be too simplistic to be able to test 7- and 14 year-olds objectively. Szende's (1977) most important theoretical objection to the test is that it is independent of any concrete goal of education.

Over several decades Edwin E. Gordon developed musical tests which are still used in the United States. Gordon's Prymary Measures of Music Audiation (1986) was designed for kindergarten children and 1st-3rd graders in primary schools. It comprises a tonal and a rhythmic subtest with 40 pairs of tasks each, and children are asked to make a same/different judgment. Gordon Musical Aptitude Profile (Gordon, 1965) is designed for 10-18-year-old students. It is made up of several subtests, e.g. tonal imagery (memory, harmony and tonal), rhythm imagery (tempo and metre), musical sensitivity (phrasing, balance and style). In the tonal imagery and rhythm imagery tests, the items consist of pairs of phrases, and students have to determine whether the items are the same or different. In the subtest of sensitivity, the pairs of phrases differ in terms of musical expression (phrasing), endings (balance) and tempo (style), and the pupils are asked to decide which is the better of the two. The strength of this test is that it has an excellent reliability (Cronbach's alpha of 0.9).

Music achievement tests, on the other hand, are dependent on the given educational system, since they test musical theoretical knowledge (names of sounds and rhythms, time signatures, music symbols, scales, and music history), as well. The common property of music achievement tests is that all of them test skills related to notation.

Gordon's *Iowa Tests of Music Literacy* (1991) includes a *Rhythmic Concepts* division with three subtests. In *Audiation/ Listening*, the participants discriminate between patterns in which beats are subdivided into duplets and triplets. *Audiation/ Reading* requires determining whether aural patterns match notated patterns. The *Audiation/ Writing* section requires filling in noteheads, flags and rests to make a notated pattern match an aurally presented pattern.

1.6. Research on musical skills in Hungary

The first research studies in connection with musical abilities in Hungary were conducted by Sándor Kovács, who applied the results and techniques of experimental psychology in the field of musical abilities in the first decades of the 20th century. Kovács' experiments focused on the capacity and characteristics of musical memory, mostly in connection with music reading (Dombi, 1992). In 1916, Géza Révész made an intensive study of the young Hungarian pianist, Ervin Nyiregyházy. Révész (1946) measured musical skills in three age groups using rhythmic and pitch reproduction, resolution of intervals and chords, interval reproduction, sense of harmony, vocal reproduction of unknown melodies, reproduction of known melody on the piano and improvisation.

Endre Szeghy implemented the first large-scale measurement of musical skills, when he tested 2000 primary school children in Hungary. Similarly to Révész, he focused on rhythmic and melodic reproduction, vocal interpretation, musical memory, sense of style, and musical empathy skills (Dombi, 1992). In the 1960s, Zoltán Kodály encouraged a four-year, and multi-institutional type of study launched by Klára Kokas that systematically tracked children who regularly studied music in school effectiveness. The results showed a better outcome for children involved with music for activities related to arithmetic, writing, and creative problem solving and in the area of movement in contrast with their normally educated peers who were not involved in music (Barkóczi & Pléh, 1980). This exploration of musical education pointed out the transfer effects that proved that regular musical activity results in a positive change in other non-designated areas of knowledge (Kokas, 1972). The generative effects of music were proved by the analysis of music psychologists Iván Vitányi, Zoltán Laczó, Judit Gál, and the sociological essays of Ágnes Losonczi. The works of Ilona Barkóczi, and Csaba Pléh from the 1970's have also had greatly significant effects; they discussed the transfer effects of music and the importance of everyday music learning in children's personality (Czeizel & Batta, 1992). The basic purpose of their investigation was to discover the overall effects of Kodály's musical training on the development of intellectual processes and on personality (Barkóczi & Pléh, 1980, p. 129). The results imply that musical education might have a possible compensatory effect in the development of creativity and the modification of the structure of intelligence. Correlations between creativity and intelligence also increase due to musical education, with regard to the relationships between personality and intellectual performance. The results suggest that high creativity is combined with emotional sensitivity and inner control in children exposed to more music, and they tend to mobilize energy and activity in the convergent tasks requiring more disciplined thought (Barkóczi & Pléh, 1980, p.134).

To examine the effects of the Kodály concept, Székácsné led a comparative survey and analysis to explore the impact of intense musical skill development in the use of visual language. She followed the development of graphic abilities in music and mainstream schools in Kecskemét for three years. Székácsné (1980) explored musical and verbal-visual transfer and found that initial differences in visual skills were higher in the specialized music schools. The area of intervallic hearing, its nature and pedagogy were examined by Szende (1977). According to Szende, musical hearing, as a judgement of the quality of the sound is a function of musical imagination, which is decisively influenced by aural training (music education), musical practice, and the surrounding world -the tonal world of a particular society -in which students live and are informed.

In the 1990s, József Nagy defined the *Model of basic musical skills* (Table 3) based on the research of Erősné, Fodor and Pethő. The two-dimensional construct is still the most influential conceptualization of musical skills in Hungary. Five musical dimensions (melody, harmony, rhythm, dynamics and tone) are separated and four types of information-giving in musical communication (hearing, conveyance, reading and writing) are distinguished in the model (Czeizel & Batta, 1992). This model was a starting point for other Hungarian musical skill tests (e.g. Turmezeyné, 2007 or Janurik, 2010).

Table 3 Model of Basic Musical Skills (Erősné, 1993)

	Hearing	*Conveyance*	*Reading*	*Writing*
Melody	Melody –hearing	Melody – conveyance	Melody – reading	Melody – writing
Harmony	Chord – hearing	Chord – conveyance	Chord – reading	Chord – writing
Rhythm	Rhythm – hearing	Rhythm – conveyance	Rhythm – reading	Rhythm – writing
Timbre	Timbre – hearing			
Dynamics	Dynamic – hearing			

The test developed by Erősné (1993) examines musical perception, singing ability and skills related to music notation. It has a great significance, because unlike other popular music tests, it focuses on students’ singing, music reading and writing skills between the ages of 10 and 22. The test battery contains 61 items listed in 14 subtests. The measured musical skills are defined as basic musical skills. Reading skills are tested by comparing and reproducing musical notation. Erika Turmezeyné Heller explored the development of musical skills in 7- to 10- year-old children in a longitudinal study between 2004 and 2006 (Turmezeyné, 2009).

Márta Janurik and Krisztián Józsa developed a test for kindergarten-age children. The researchers explored the relationship between musical performance and other cognitive variables, such as writing-movement-coordination, spatial relation, vocabulary and social skills' DIFER index improvement, related to musical perception in children from 4 to 8 years in a cross-sectional study with 657 participants (Janurik & Józsa, 2013). Buzás and Lele (2013) carried out an online questionnaire among conservatory students between the ages of 14 and 20 on the basis of the Kodály concept. Their results reflect Hollenbeck's (2008) studies with instrumental students in the United States. She examined the cognitive, metacognitive and affective skills of instrumentalist students. The results show that 61% of the conservatory students think that they have appropriate music memory, 70 % of them have clear intonation and 73% have accurate rhythm skills. 64% of the students understand music vocabulary, musical expressions and signs, 57% are able to analyze folk music and 61% can analyze classical compositions. Only 53% of the students can sight-read, 47% can recognize and recall different musical time periods, styles and composers. 40 % are able to read music in different C-clefs, 39% can transcribe music and 34% are able to improvise.

In the research of Asztalos and Csapó (2014) a music ability test was administered through an online assessment platform. The sample consists of 155 students from a music primary school and 498 students from non-music schools. The reliability of the test was excellent with a Cronbach's alpha of 0.917. The age group results show that musical abilities develop most dynamically during the first school years. In their research, they used visual connection tasks to examine the basic ability of music reading and writing, the relationship between the acoustic input and visual signs. They found that the performance of students from music primary schools was significantly better than that of regular primary school students. The reason for that is that music reading and notation have an important role in music school curricula as early as in the first few years.

1.7. Music perception skills

Musical hearing is an extremely complex phenomenon. Since it has evolved in the historical processes of the development of human society, it is a rather unique physical ability, which is obviously, different from the simple biological fact of hearing in animals (Szende, 1977). At the lowest stage of human evolution, musical perception was primitive; it was simply responsiveness to the rhythm of primitive dances and singing. In the course of this evolution, human sense of melody developed and became refined and later polyphonic music and sensitivity to harmonics evolved. Musical hearing can be regarded as a unified, interpreted and generalized perception ensuring the development of musical culture as a whole, while Teplov (1960) uses the term musical hearing to refer only to pitch discrimination. According to Dowling and Harwood (1986), sounds have four main psychological qualities which are particularly important in music. These are pitch, timbre, duration, and volume. On a higher level, the musical hearing is a very complex acquired skill, which involves the discriminations of pitch, timbre, melody, harmony and tonality (Szende, 1977). In Moles' conceptual framework (1969), musical phenomena may be divided into two main fields: successive and simultaneous processing. The components of musical abilities are rhythm and tempo and their discrimination, melody discrimination, pitch discrimination, polyphonic hearing, timbre and dynamic hearing abilities (Asztalos & Csapó, 2014).

1.7.1. Rhythm

Rhythm is successive; it is one of the time-component dimensions of music. According to temporal proximity and metric organization, the grouping of events can be defined as basic temporal regularity or pulsation. Every culture has some form of music with a beat, a perceived periodic pulse that dancers use to guide their movements and performers use to coordinate their actions. Western music duration notation is detailed and has been developing since the 15th century. The three levels of rhythm – beat, subdivision of the beat, and grouping of beats – combine to establish the definition of meter (Ester, 2010). Meters can be categorized as duple or triple (according to whether the beat or pulse is organized in twos or threes) and as simple or compound (whether those beats are subdivided into duplets are triplets) (Table 4).

Table 4 Basic metric categories (Ester, 2010, p.28)

	Binary pattern of beats	*Ternary pattern of beats*
Subdivision by twos	simple duple: 2/4, 4/8	simple triple: 3/4, 3/2
Subdivision by threes	compound duple: 6/8	compound triple: 9/8

Rhythmic perception is a prominent area of research in music cognition and advised to be improved with regards to age and musical training. Specific training programs can fit certain age-groups to facilitate the development of rhythmic perception. There is diversity across cultures in the complexity of rhythms used in music. Enculturation to rhythm develops in infancy. Western infants of six months of age have no difficulty detecting disruptions to both simple and complex meters, but by the age of one year, they detect only disruption to simple meters (Hannon, Soley & Levine, 2011).

Drake (1993) finds five-year-olds able to perceive and reproduce rhythm sequences utilizing the beat in both binary and ternary subdivisions. By the age of seven, children are able to reproduce complex rhythm patterns nearly as well as adult non-musicians. School-age children perceive and comprehend two levels of rhythm: the beat and the beat-subdivision. However, more experienced students can focus on a third level of meter: beat groupings (Ester, 2010). Lucchetti, Caccio and Beni (1997) devised an experiment with three different tests: one test on *duration*, one test on *rhythm*, and one test with *nursery rhymes*. Each section required the participants to compare musical excerpts and determine differences of time or duration between them. There were over 200 students from the third to the fifth grade. Researchers observed a drastic improvement in the ability of rhythmic perception between the passages from third to fourth grade in primary school between 9-11 year-old students, which suggests a developmental period for rhythmic perception during these age years. An acceleration process can be observed in several fields of musical skills, which is due to the almost continuous musical inputs, which surround children in the urban environment and also at home. This process is often referred to as media effect (Shuter-Dyson, 1999).

In his research Perney (1976) examined the relation of musical training, verbal ability and the combination of gender and grade on second and third graders' development of rhythmic skills. Perney's most important finding was that age alone does not determine the performance of musical tasks, and verbal ability is more closely related to musical performance. He found a significant correlation between students' verbal ability and their ability to perform in the rhythm tasks.

1.7.2. Melody

The third dimension of music is the melody. It also has a time-component. Melody is defined as a succession of pitch sounds within a rhythmic framework (Lowery, 1952). Sounds have a meaningful relation to each other primarily in terms of musical intervals and note-lengths, so melody has tonal and rhythmic elements. According to Turmezeyné and Balogh (2009), the perception of the sounds as a melody, is composed of the following ingredients: the perception of the intervallic steps of the successive sounds, the direction of the movement of the sounds, and the perception of the melodic contour. For improving melodic hearing, the first step is to recognize the melody line (Teplov, 1960, p.133); later students are able to recognize and reproduce its components.

According to Peretz and Zatorre (2003), the encoding of pitch of musical scales and the ascribing of regular beat to incoming events were the two principal steps of brain specialization for music. The first studies in music psychology in the first decades of the twentieth century focused on how listeners perceive and process single musical tones and empirical data were collected about the perception of pitch, loudness, and timbre. The perception of single pitches does not necessarily precede the perception of groupings of multiple pitches, so the discrimination of single pitches is not the prerequisite to the perception of musical units. As memory research predicts, the musical context plays an important role in tonal perception, just as it does in the perception of rhythm (Ester, 2010).

Critical developmental periods are related to the perceptual development of the three basic aspects of musical pitch structures. A clear developmental period of the acquisition of musical pitchstructure emerges very early, with sensitivity to consonance and dissonance. Sensitivity to scale structure emerges within the first few years, with sensitivity to harmonic structure beginning to emerge late, around the age of six. Sensitive periods for higher levels of musical expertise are more fluid, and there are multiple ways to achieve musical expertise (Trainor, 2005).

Around the age of five, children can organize songs around stable tonal centers (Dowling, 1999) and they are able to discriminate between major and minor scales (Jordan-DeCarbo & Nelson, 2002). By the age of eight, students' melodic perception operates within an increasingly stable tonal system and they can distinguish between the pitches of the tonic triad and the other pitches within the key (Dowling, 1999, cited in Ester, 2010).

Takeuchi and Hulse (1993) have identified a possible sensitive period for the acquisition of absolute pitch that ends around six years of age. The presence of absolute pitch as measured in adulthood is strongly associated with early musical lessons before the age of six years. According to Crozier (1997), a specific training on absolute pitch is more successful with children under six than over six years of age. Larmont (1998) investigated the role of formal music education in the development of melodic perception. He came to the conclusion that enculturation has more importance at the age of 6-10 than education. After the closure of the musical sensitive period, only those students show development in melodic perception skills who receive specialized education in music.

Enculturation is a determining factor of the musical life of humans. We are basically sensitive to the special aspects of musical system of the culture we were born in. Acquiring culture-specific implicit knowledge about the music to which students are exposed is similar to the language acquisition techniques which they develop. The knowledge of the principal structures of Western music, for example scales or harmonies, develops during childhood (Krumhansl & Keil, 1982, Trainor & Trehub, 1993). Prenatal, or early postnatal exposure in a certain musical tradition would be equitable with the notion of biologically based attentional or learning preferences. In Western tonal music listeners could progressively elicit the regularities and traits (Krumhansl, 1990) and build implicit theories or schemas that guide future experiences (Schmuckler, 1989, 1990).

Krumhansl (1990) has defined a hierarchy for Western tonal music that reflects the degree to which individuals perceive pitches as fitting with an established tonal context. The contexts consisted of scales and common chord cadences designed to imply a tonal centre. Students consistently rated the pitches of the tonic triad (e.g., C-E-G in C major) significantly higher than any other pitches, with the remaining diatonic scale tones (D, F, A, B in C major). While Western adults are much better with Western scales (Lynch, Eilers, Oller & Urbano, 1990), infants appear to be open to learn any musical pitch system, as they show equal performance in discriminating between mistunings in Western and in Indonesian scales. Trainor and Trehub (1992) demonstrated that adults without formal musical training found it easier to discriminate between a change in one note of the melody when the change went to a note outside the scale of the melody in comparison to when the changed note remained within the tonality of the melody. Infants are able to discriminate between both types of changes equally well, even outperforming the adults. These findings are consistent with studies of song production, which have shown that younger children wander considerably in pitch, but begin to use consistent tonality after the age of five years. Thirteen-year-old children with musical training show a greater aptitude for detecting mistuning in Western scales than in Indonesian scales by comparison with children having no musical training (Dowling, 1999).

1.7.3. Dynamics

In the dynamics as a musical dimension, duration and volume are added up, so dynamics has a time-component with a successive dimension. During the changes in the dynamics we follow the process of volume change. The loudness of sound can be characterized by generated sound pressure, the amplitude or intensity. In dynamics the matter of volume is always relative, we always correlate the circumstances of the particular performance. Several different types of dynamics, both in written and signed forms, can be distinguished. A common feature of volume and tone hearing is that one of them can be treated purely as a musical skill, since the contents of the volume and tone of information identification, perception and evaluation of daily life plays an important role (Turmezeyné & Balogh, 2009). Dynamic hearing also shows a rapid improvement. At the age of 10, students can perform well in the tasks of dynamics recognition (Turmezeyné, 2007).

1.7.4. Timbre

The fourth dimension of musical skills is timbre-perception, which is simultaneous, without a time component. Timbre is the quality of a musical sound. Timbre has two main properties which contribute to the perception of music: 1) it refers to a set of sensory attributes (e.g. sharpness, brightness or nasality) and 2) it is one of the primary perceptual vehicles for the recognition, identification and tracking of a sound source (e.g. voice of singers or instruments) (McAdams & Giordano, 2009). The timbre of the instruments depends on the material and the form of the instrument or how the musicians play it. The same musical instrument, e.g. a violin or a piano, does not have the same timbre in the hands of different performers (Janurik, 2010). The latest electronic and computer technology promises access to an unlimited world of timbres.

Timbre can contribute to larger-scale musical form, and in particular to the sense of movement between tension and relaxation. This movement has been considered by many music theorists as one of the primary bases for the perception of larger-scale form in music (McAdams

& Giordano, 2009). As Trehub's results (1990) show, even 6-12 month-old children can distinguish between timbres of different instruments successfully. The most dynamic development of timbre perception skills can be observed between 4 and 6 years (Schellenberg, 2006).

1.7.5. Harmony

Harmony is a simultaneous musical dimension that does not include a time component. According to Erősné (1993), harmony hearing, like melody hearing, is based on the perception of tonality and also on the recall of music patterns. These two types of hearing are always manifested and interwined, and their relationship characterizes hearing as a whole. A harmony, e.g. a triad is a chord built on thirds. The configuration of a harmomy includes the root, the third, and the fifth. The third is a third above the root, and the fifth is a third above the third. Depending on the quality of these two intervals, the quality of the triad changes. We can distinguish major, minor, diminished and augmented triads. In addition to diatonic triads, every major and minor scale has seven diatonic seventh chords. Harmonies are either consonant or dissonant; the latter may be an unpleasant sound to the human ear. Prefering perfect intervals (perfect fifths, fourths and octaves) is a characteristic that humans are born with. Even infants can distinguish between tritons and perfect fifths or fourths (Schellenberg & Trehub, 1996). The medium also has an effect on the development of the perception of consonance and dissonance, as well (Imberty, 1969).

1.8. Singing

The ability to use voice to express music through singing is a universal characteristic of all known music cultures. Each culture has a tendency to value particular vocal timbres in the performance of its art music, such as the solo vocal sounds usually associated with classical opera in the Western cultures, or the unique sound of the throat music of Mongolia.

One of the basic concepts of Zoltán Kodály's is that the most direct path to an insightful understanding of music is through singing. The breadth of opportunity for musical education inherent in singing stems in the first place from the fact that everybody can do it. This is the skill where students must be able to use their voices including correct breathing, posture, expressions, and intonation (Houlahan & Tacka, 2008).

Singing uses the same vocal apparatus as speech. Singing, like language, is based on auditory processing. The vocal instrument consists of three basic components: the respiratory system, the vocal folds, and the vocal tract; the cavity formed by the spaces above the larynx; the pharynx and the mouth, which are sometimes complemented by the nasal cavity (Sundberg et al., 1996). The close relationship between music and speech can be observed by the infants' lallation that is similar in every culture. Babies' lallation guidance is often identified as a musical activity which includes musical characters such as repetition, high-pitched voice, wide and slow pitch contours, all characteristic of upstairs-downstairs patterns (Fernald, 1989). This possibility is consistent with recent evidence that the melodic character of this early vocalisation may be a predictor of future language development. Around 18 months of age children's vocalisations start to remind the listener of recognizable songs, mostly as short musical phrases repeated (Dowling, 1999; Welch, 2006).

Stable pitch contour and regular beat patterns, except for tonal stability, which is mastered later, appear around five years of age (Dowling, 1999; Dowling & Harwood, 1986). The closure of the sensitive period related to singing occurs at the age of eight when the children are able to repeat a song properly after hearing it. Without further education, it will stop developing (Davidson & Scripp 1990).

1.8.1. Amusia

There is no evidence that musicality is a universal human property, but according to the research of Cross and Morley (2013), people with a few exceptions can be involved in musical processes and activities. In Western cultures, even those who do not consider themselves so talented as to participate in musical activities are able to show a certain level of understanding in the music listening process. The term tone deafness is usually associated with poor perceptual abilities, and refers to congenital amusia (Ayotte et al., 2002; Foxton et al., 2004; Peretz, 2001). Congenital amusia is a neurogenetic disorder affecting a small percent of the population (Kalmus and Fry, 1980; Peretz and Hyde, 2003; Peretz et al., 2007). This condition can be uncovered by a battery of tests including pitch and rhythm perception and incidental memory tasks. According to the results of the *Montreal Battery of Evaluation of Amusia* (Peretz & Coltheart, 2003), amusia is very rare, with only 2% of the population have results below the average. Congenital amusia is associated with brain anomalies in the right inferior frontal cortex (Hyde et al., 2006) and in the right auditory cortex (Hyde et al., 2007). Because of the variety of musical skills there are more types of amusia, such as receptive amusia that is connected to music listening or expressive amusia which means the lack of ability to express music (singing, playing on a musical instrument or even music reading) (Papp, 2004).

1.8.2. Intonation

Intonation refers to pitch discrimination, which can be defined as the skill to distinguish between two successive pitches or two dissimilar examples of a single pitch (Morrison & Fyk, 2008) or the manipulation of pitches and intervals within a real musical context. Lerners at any level of music education can sing cleanly and appropriately only with practice. At the most basic level of singing students operates within a very limited context, focusing only on themselves and their actions. At the next level students become more aware of the different kinds of sounds they are able to produce, as the results of their physical processes. They are also able to select from and perform a variety of pitches that have become part of their repertoire. At the most advanced stage, students not only compare the relationship between their sounds and that of others around them, but they can also compare it to an abstract standard, a musical ideal. They can manipulate their own actions so that the result is not only correct but also expressive. The musical context has extended beyond their immediate environment to include an awareness of historical and cultural – professional – standards. In his study, Green (1994) focuses on the benefits of group singing compared to solo singing. His results showed that children sing with better intonation in a group than alone.

In his book, Let Us Sing Correctly (1941a), Kodály includes 107 short, three to twelve note exercises designed to practice intonation. When working with music reading, it is important to take into consideration the musical context. Intervals may be perceived and performed with slightly different intonation inflections when in different contexts.

1.8.3. The transfer effects of group singing

One of the central parts of Zoltán Kodály’s concept is the choir, the most natural way of common music-making. In his writings on music education, preserving cultural heritage and the importance of group singing regularly appear together. Kodály suggested that students should sing in a choir, which strenghtens group cohesion and national unity can be based on singing communities, like in England. In the 1930's Lajos Bárdos, one of Kodály's student, initiated the *Movement of Singing Youth,* in which about 50,000 choir members took part in the firts ten years of its history, and the tradition is still alive in Hungary (Pethő, 2011). The relationship between arts participation and health has received significant and growing academic, media, and public attention over the past four decades. According to a survey in the United States, about 42.6 million people sing in a choir. The number of choir singers reached ten million in 2009, with 270.000 active choirs across the United States. The children who are members of the American choirs show better performances in mathematics and English (Chorus America, 2009).

Clift and Hancox (2001) report that 71% of singers in a university choir agreed that singing was beneficial for their mental wellbeing. Hillman (2002) reports a significant perceived improvement in emotional wellbeing among participants singing in a large community choir. A number of studies have also shown significant improvements in affective state after singing, using previously validated mood questionnaires (e.g. Kreutz, Bongard, Rohrmann, Grebe, Bastian & Hodapp 2004; Unwin, Kenny & Davis 2002).

Clift and Hancox's study (2010) undertakes a large-scale, cross-national survey of 600 singers in choirs in England, Germany and Australia. They relied on the WHO definition of health, and used a cross-national instrument for assessing health-related quality of life, the WHOQOL-BREF questionnaire (Cronbach's alpha of 0.9). Their aims were to assess physical, psychological, social and environmental well-being, on *a well-being and choral singing scale*. The results revealed that, a large majority of choristers perceive the experience of singing to be a positive and beneficial one. Community music activities' benefits extend to the group and, in some cases; it can solve conflicts and develop empathy between different groups. Furthermore, choirs can be applied as a preventive tool for reducing risk-seeking behavior (Morrison & Clift, 2012).

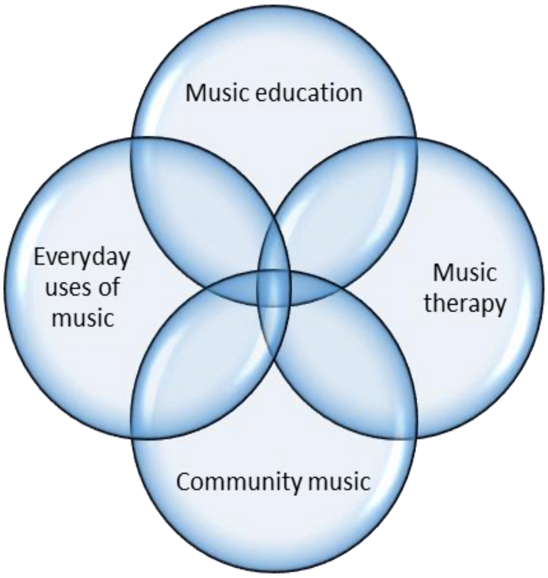
Children can have very different singing skills when starting school. The level of their development depends on the age of the child, and how often they are involved in singing games, and participate in group singing (Welch, 2006).

Several music therapy programs use active rhythm playing and singing in order to facilitate the recovery of brain areas of speech, hearing, movement and emotional connection. Symptoms of several neurological and psychiatric diseases can be relieved with music therapy (Thompson & Schlaug, 2015). During the musical experience the biochemical mediators, such as endorphins, endocannabinoids or dopamine play an important role. Dopamine is both neuroendocrine- transmitter (Bentivoglio & Morelli, 2005) and neurotransmitter (Lookingland & Moore, 2005) both of which activate dopamine receptors in the nervous system. The results indicate that intense pleasure in response to music can lead to dopamin release in the striatal system. Listening to music, but rather as a result of active music making dopamine is released in the brain, which has a role for in creating pleasure in the rewarding and reinforcement operation, or the integrity, freshness of thinking is dependent on it (Salimpoor et al., 2011).

Dopamine is also essential to establish and maintain well-being. As a neurotransmitter, the dopamine has a role in the coordination of movements, in motivation, emotion and reward-prediction, as well as being dependenent on the development of working memory and executive functions. These common musical activities not only compensate for the changes caused by stress in the immune system, but also slow down the ageing process (Koyama et al., 2009).

Bailey and Davidson’s (2005) research showed four areas of the transfer effects of choral singing: 1) usability in health therapy, 2) social benefits for the community, 3) positive cognitive processes, 4) the affective aspect - the benefits of the choir and of social relations. *The Conceptual Model for Music, Health and Well-being* was developed by MacDonald, Kreutz, and Mitchell (2012) and has four main areas, including music education, music therapy, community music and all-day music. Figure 1 presents this model. In this concept, music education has a lot to contribute to the health and well-being of students. Certainly the primary function of music education is not therapeutic or social; however, many music educationalists are interested in the wider benefits of music teaching.

Fig. 1 Conceptual framework for music, health and well-being (MacDonald et al., 2012, p.8)



1.9. Musical memory

Music memory is a critical skill for the development of all musical skills. Auditory, kinesthetic and visual information contribute to musical memory. Memory strategies depend on the skill of the performer and the style and difficulty of the music to be memorized. The ability to memorize seems to be enhanced by studying music theory and solfege (Aiello & Williamon, 2002). Bentley's (1966) research indicates that most children reach the stage of analysis in both the tonal and rhythmic aspects of memory by the age of eight; they can remember the exact place in the melody or in the rhythmic pattern where a change occurs in the second presentation.

Clarke (1988) says that performers retrieve and execute compositions using internal musical representations. To play from memory students must understand a piece at different levels, from a complete hierarchical memory of the entire piece down to the smallest detail. The depth to which the generated structure is activated is directly related to the structural significance of musical phrase boundaries. At a phrase boundary the performer needs to know how the phrases relate to one another and to the overall structure of the piece. Therefore, when learning a piece, performers must strive to develop their memory of the overall structure of the composition and the way phrases and sections follow and relate to one another.

1.10. Inner hearing or audiation

Inner hearing or aural imagery means the internal conception of how notes, intervals and chords are arranged in time and pitch. It is a lengthy and complex process to develop the internal ear for music. Educators identify the development of comprehensive aural understanding as an indispensable component in the acquisition of music literacy. Engagement in audiation allows musicians to listen, to read, write, perform, and create music with depth of perception and understanding (Gordon, 2007).

Audiation (Gordon, 1980) is closely linked with musical practice, and the ability to do this depends on the level and amount of preceding practical experience. Audiation activates already established familiar music patterns that are stored as mental representations. Therefore, any learning efforts should be directed to establish mental images prior to the training of mere motor or reading and writing skills. The development of inner hearing begins at a pre-school level and has an important role throughout the entire duration of the music-school education system (Ester, 2010).

1.11. Improvisation

According to Kenny and Gellrich (2002), improvisation is a performance of art, requiring preparation across a broad range of musical and non-musical formative experiences, and also a sophisticated and eclectic skills base. Aside from the cognitive (i.e. memory) and physiological (i.e. motor skills) constrains that affect improvisation, the most important internal element is the knowledge base. The learned material contains the followings: musical repertoire, perceptual strategies, problem-solving routines, hierarchical memory structures and schemas, generalized motor programs (Pressing, 1984). Within the context of the Kodály philosophy, improvisation is connected to the practice of known musical elements that enable students to create their own improvisations using external patterns and elements. Improvisation permits students to create spontaneously rhythms, melodies, movements and new forms as well as new texts to adhere to the basic melody. Students may improvise a musical answer to the instructor’s musical question. For example, if the instructor claps a question rhythm using rhythmic syllables, the students may clap and say a different rhythm in response. This same technique may be achieved melodically using solfege syllables. Improvisation activities can be extended by changing them into composition activities.

1.12. Form and style recognition

Form and style recognition refers to the phrase structure of a piece of music. Students need to be able to determine both the rhythmic form and the melodic form of a piece of music, both aurally and visually. Determining form begins with the ability to identify the same or different forms and similar phrases usually through the process of singing play-songs. The ability to identify form significantly affects the development of musical memory.

It is possible for listeners to form expectations of the forthcoming events in music, even if they are not familiar with a particular musical piece. Two kinds of expectations can be distinguished: in schematic expectancy, expectations are influenced by other music and musical stlyles with which the listener is familiar whereas in veridical expectancy, expectations are influenced by the knowledge of a particular piece of music. Repetition and musical forms such as rondo form, and four or eight bar phrases, or periods organized in certain structures such as AABA or AABC, create more plausible structural expectations that are based on clear repetition. Expectations concerning the timbre, instrumentation and texture also exist. These expectations make form and style recognition more effective.

1.13. Music writing

There is more and more evidence that learning of written language improves the existing neural mechanism for spoken language (Van Atteveldt et al., 2004 cited in Csapó & Csépe, 2012). Written language is a relatively recent cultural invention which came into existence some 5,000 years ago (Rayner & Pollatsek, 1989, cited in Csapó & Csépe, 2012), but remained the privilege of only a very small proportion of the human world population until a few hundred years ago. In all cultures word literacy preceded music literacy. The earliest known musical notation is based on the alphabetic principle of one pitch means one symbol. The notational methods in most cultures share similarities, many of them are alphabetic notations, using words, syllables, or letters to stand for single sounds or a fixed pitch (Cole, 1974, p. 6). The importance of music notation in Western musical traditions is underlined in educational practices and concepts, such as those developed by John Curwen, Emile Jacques-Dalcrose and Zoltán Kodály, where music notation is the key element in pedagogical practice. During music writing students translate the sound of music into a music symbol using rhythmic notation, or staff notation. Music notation is a form of intra- and inter-musician communication that rests in particular traditions of generating and transmitting meaning. It serves several purposes, including the conservation of music, the communication of music, and the conception of music. Music notation serves as a memory aid, and makes possible the learning of musical works independent of the originator (Ester, 2010).

Gromko and Poorman examined children between the ages of four and thirteen who were enrolled in a private school. Their goal was to determine whether musical aptitude is related to children's ability to use symbols. In an initial testing session, children completed the tonal subtest of Gordon's musical aptitude measures. During a second session, children were tested on two tasks, one that required them to match short melodies with graphic representations and another that required them to draw graphic representations of the contour of short melodies. Performance on all of the three measures improved with age, and each measure correlated significantly with the other two. These findings confirm that children's musical aptitude is predictive of their ability to interpret and produce symbolic representations of music.

The notation of time and pitch are stable elements of musical sound; however, timbre and dynamics are not fixed. The values indicated by signs f, m, p, or pp, are dependent on the musical context. The amount of detail in dynamic marking varies according to the practical and aesthetic views of composers (Cole, 1974).

1.14. Spatial and orientational abilities

Connecting the visual and auditive stimuli forms the basis of music reading and writing. The symbols of the musical notation and their position carry meanings both in the vertical and horizontal dimension. This is the reason why spatial and orientational abilities play a more important role in music reading than in word decoding (Fazekasné, 2006). Gromko (2004) claims, when skilled musicians read musical notations they may actually be mentally representing the sound as an image with both spatial and temporal dimensions. Music reading ability can be predicted by a combination of four cognitive abilities. 98 high school band students participated in his research, and the predictors investigated in this case were the subjects' scores on the Gordon's *Advanced Measures of Music Audiation Test* (1989) (musical aptitude), Holzman's *Schematizing Test* (Holzman, 1954, visual field articulation), the *Kit of Factor Referenced Cognitive Tests* (Ekstrom, et al., 1976, spatial orientation), and the *Iowa*

Tests of Educational Development (Hoover, et al., 2003, academic achievement). The students' sight reading ability was indicated by their scores on Form A of the *Watkins-Farnum Performance Scale* (1954). Gromko's regression analysis yielded four independent variables that predicted expertise in sight reading: 1) reading comprehension, 2) rhythmic audiation, 3) spatial orientation and 4) visual field articulation (ability to focus on a specific item embedded in a pattern). Rhythmic audiation's found rhythmic sight reading to be the best predictors of music reading ability. Visual field articulation was negatively correlated with music sight-reading ability. Students who scored high on visual field articulation focused on each individual component of the pattern. These students scored lower on music-sight reading, which requires focus on musical pattern, rather than individual notes.

According to Hayward and Gromko's (2009) research with university pianist students (N=21), aural skills, spatial reasoning, and technical proficiency are predictors of sight-reading skills. The initial analysis found a strong correlation between technical proficiency and sight reading ($r=0.70$, $p<0.01$). The results of the regression analysis found aural-spatial skills and technical proficiency to be both strong predictors of sight reading ability.

Bilhartz, Bruhn and Olson (2000) found a significant connection between early music instruction and spatial abilities. A structured music curriculum and cognitive development with 3- to 6-years-olds (N=71) was explored. The experimental group (N=36) received 75-minute music lessons a week for 30 weeks, while the control group (N=30) had no music lessons at all. Significant gains are shown for children who participated in music instruction on a spatial memory subtest from the *Standford-Binet Intelligence Scale* (SBIS, 1986), the *Bead Memory* subtest.

1.15. Digital literacy and digital skills

In European music schools and conservatoires, solfege is the discipline which targets music reading. Many music students learn it with declining enthusiasm, probably because it is a compulsory subject. Without an elaborate music curriculum, solfege can frustrate *digital native* students rather than motivate them (Sagrillo, 2016).

Prensky invented and popularized the terms *digital native* and *digital immigrant* in a 2001 article in *On the Horizon*. D*igital native* are the people who grew up with the technology that became prevalent in the latter part of the 20th century, whereas a *digital immigrant* is an individual who was born before the existence of digital technology and adopted it to some extent later in life. The spread of the digital culture was accelerated by the appearance of the internet, which has changed writing, as well. Communities on the internet are very popular. The term *Media Literacy*, which was first used by Auferheide, appeared in 1992. Music students, and students in general are faced with learning multiple new literacies to succeed in our fast-paced, information-rich world, yet most schools have not caught up with the digital reality that students live in daily. Lately more than 30,000 musical applications have appeared on IPad and more than 7000 on android software (Sagrillo, 2016). Research is needed in Hungary into the facilities in music school and conservatories in connection with ICT. According to Kárpáti (2008), the measurement of ICT skills among students has been integrated into the examination of other areas; however, only a few pieces of research have been conducted with students in the field of music education. According to Janols (1990), the new technology has increased students' sense of the basic elements of music. Savage (2005) has sought to bring to classroom teaching electro-acoustically produced shapes of music and create activities involving combining sounds and images.

Research into computer-assisted music education started at the end of 1960s in the United States and the United Kingdom. The first computer programmes were intended to be ear-training exercises (Raynold, 1967). More and more young people use technological tools as musical instruments. Basic research questions have arisen how ICT tools can enhance the music skills of students in music lessons and in what areas these tools become more efficient and how music education can respond to the challenges of new technologies.

The use of ICT tools not only impoves the students' music skills, but at the same time it also develops their digital competence. Basic computer skills can also increase the students' labor market opportunities in the future. Although ear training programs are often used abroad (*EarMaster Pro, GnuSolfege* etc.), Hungarian music teachers rarely use any kind of ICT tool in solfege lesson (Buzás, 2012).

2. Research on music reading

In the second chapter, I summarize the components of music reading skills and analyze the similarities between reading and music reading. I am going to give an overview of the results of the studies which attempt to explore the connections between phonological awareness and musical skills. The metacognitive aspects related to music reading indicate the connections between music learning and reading. At the end of the chapter, I will introduce empirical studies on music reading skills conducted with eye-tracking technology.

2.1. Components of music reading

A great body of research has been conducted on reading, while reading music has received much less attention. Furthermore, to my knowledge there are no comprehensive theories of music reading. This is interesting, because music (including music reading or even writing) plays an important role in music education.

The notion of shared brain circuitry of language and music is gaining increasing attention, and it can be assumed that they have common properties in terms of cognitive processing. Patel (2003, 2008) introduces the *Shared Syntactic Integration Resource Hypothesis* (SSIRH) for this overlap following Sloboda (1985). According to Patel, it is necessary to choose a particular type of music, because the syntax of music is not homogeneous either within or across cultures. The reason why he chose western music is that there is a large body of theoretical structural analysis of tonal Western music. Certainly, languages and music are different in form and the use of their syntactic structures. For example, languages use grammatical categories which are not found in music (e.g., nouns and verbs), and vice versa (e.g. intervals, chords) (Swain, 1997). Both language and music perception depend on memory and the perception of structural relations between elements. Patel and Peretz (1997) claim that music and text are inseparable in the long term memory. It is difficult to remember the melody of a song without remembering its words, and vice versa.

During music reading, special visual symbols are converted into sounds, which can be produced internally or externally via singing or using musical instruments (Hodges, 2011). Sight-singing refers to reading unknown vocal music, while sight-reading refers to reading unknown music for instrumental music.

Music reading is usually regarded as a collection of subskills. According to Wolf (1976), music reading is a complex process which involves at least two types of skills: reading skills and mechanical skills. On the other hand, Lehmann & McArthur (2002) claim that music reading comprises perception (decoding note patterns), use of memory (recognizing patterns), kinesthetics, and deployment problem-solving skills related to music (improvising, guessing). Studies find that music reading achievement at a high level is determined by the speed of information processing and psychomotor speed. This means that decoding ability and the motor response are important in music reading but the integration of these abilities may be the key to a successful execution of them. Studies on perception indicate that pitch and timing information are processed separately (Elliott, 1982).

According to Gromko (2004), music sight-reading involves audiation of tonal and rhythmic patterns, comprehension of a graphic notation system with both spatial and textual qualities, and a highly coordinated kinesthetic action in performance. Some other components of music reading skills include the knowledge of musical syntax and grammar and tonal patterns, the ability to identify notes during the process of sight reading, the individual's ability to inner-hear or audiate (Wollner & Halfpenny, 2003), practice sight-singing, employ knowledge of musical styles, engage in improvisation, make use of music memory (Lehmann & Ericsson, 1996) and deploy technical skills with many sub-skills, such as hand-eye coordination, independence of fingers, and weight controls of the fingering.

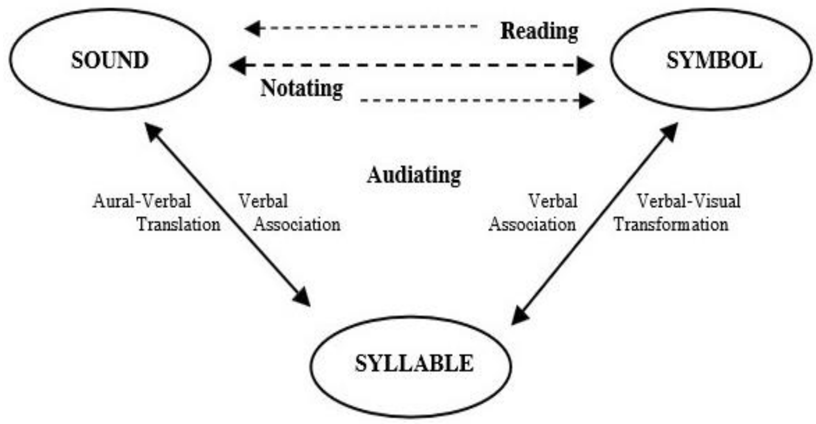
The skill to read music notation is not only a prerequisite, but it can also be a great facilitator of performing, rehearsing or composing music. In McPherson's theoretical model (1994), music reading and sight reading are different aspects of musical performance besides improvisation and playing by heart. Erősné's model of basic musical skills (1992) includes features of music reading, such as melody, chord, and rhythm reading, but neither tone nor dynamic reading. The knowledge of musical styles, improvisation, music memory (Lehmann & Ericsson, 1996), plus a person's technical skill by sight playing with many subskills can be components of music reading as well as relating to the skill of anticipation. Music reading draws on a variety of cognitive skills that include reading comprehension, audition and visual perception of patterns.

On the basis of eye-tracking studies, Besson and Friederici (1998) point out that language and music share the common tendency to evoke strong *expectations*. Sloboda (1974) discusses the issue and concludes that since incorrect performances often have similarities with the notated music, pure guessing is out of the question. Instead, he advocates a theory of sophisticated guessing, where expectations can be used to reduce the number of possible words or notes to appear as the next one based on the memorized musical patterns.

There are only a few research studies in the field of eye-tracking which deal not only with pitch and timing, but also with the other elements of a music score – like dynamics and how music signs influence sight-reading. According to Elliott (1982), rhythm reading is an important component of general music reading. He determines six predictors of music reading; technical proficiency, rhythm reading ability, sight-reading ability, cumulative grade point average, grade point average and major instrument grade point average. He concludes that rhythm-reading ability is the single best predictor of instrumentalist students' music reading scores.

In the model *The Sound Connections Learning Triangle*, which was developed by Ester (2010), rhythm and tonal syllables serve as mediators between sound and symbol. They help the students encode and store aural patterns. Once these connections are established, the syllable patterns will be associated with corresponding symbol patterns. The resulting symbol-to-syllable-to-sound connections create the coherence pathways in the brain that make music reading possible. The pathways can function just as efficiently in the opposite direction, i.e. sound-to-syllable-to-symbol, resulting in the ability to notate what is heard. The sound-syllable connection is a translation, because one sound (music) is changed into another sound (verbal syllable). The syllable-symbol connection, on the other hand, is a transformation because the change is visual into aural (or vice versa). Initially, the processes of reading and notating involve both translation and transformation because the syllables are verbalized. However, as audiation skills improve and the coherence pathways are exercised, students will become adept at converting symbol to sound (reading) and sound to symbol (notating) without needing to verbalize the syllables. This is a necessary prerequisite for effective melodic reading as it is not possible to verbalize both rhythm and tonal syllables simultaneously. Figure 2 presents this model.

Fig. 2 The Sound Connections Learning Triangle (Ester, 2010, p.31)



2.2. The role of phonological awareness in reading

The relationship between phonological awareness and music perception suggests that they may share some of the same auditory mechanisms. Phonological awareness requires the listener to be able to segment speech into its component sounds, and to recognize those sound categories across variations in the pitch, tempo, speaker, and context. The perception of music also requires the listener to be able to segment the stream of tones into relevant units, and to be able to recognize compositions across variations in pitch (key), tempo, performer, and context.

Anvari et al. (2002) have studied the relation between early reading skills and musical development on a large sample of English-speaking four- and five-year-old children. Fifty four-year-old (29 female, 21 male) and 50 five-year-old (30 female, 20 male) children were recruited from schools and daycare centers. They were given a battery of tasks, which included tests of reading (Wide Range Achievement Test-3), phonemic awareness (Rhyme Generation, Oddity, Blending, The Rosner Test of Auditory Analytic Skills), vocabulary (Peabody Picture Vocabulary Test), auditory memory, and mathematics. As far as musical development is concerned, musical pitch and rhythm discrimination were tested. The pitch tasks included discrimination between short melodies and chords, whereas the rhythm tasks involved discrimination between short rhythmic patterns and in reproduction of rhythms by singing. The results show that by the age of five, clearly separable pitch and rhythmic abilities have emerged. As expected, in both age groups, phonological awareness correlated significantly with reading. This supports the vast literature outlining the strong relationship between phonological awareness and reading skill (e.g. Bradley & Bryant, 1983). Music perception significantly correlates with both reading skill and phonological awareness. These results are consistent with musical skill being associated with enhanced auditory memory.

The most valuable findings concerned the five-year-olds. Their performance in musical pitch tasks predicted their reading skills even after the variance shared with phonemic awareness is removed. This suggests that phonemic awareness and music perception skill tap some of the same basic auditory and/or cognitive skills needed for reading. Other researchers (e.g. Barwick et al., 1989) state that reading ability correlates with the tonal memory and chord discrimination of nine-year-old children. Lamb and Gregory (1993) find that pitch discrimination is significantly related to the reading ability of five-year-olds. They presented sixteen four- and five-year-old children with pitch and timbre discrimination tasks, phonemic awareness, and a simple reading test. As expected, phonemic awareness correlated with simple reading skill. They also reported that pitch discrimination significantly correlated with phonemic awareness. In this study, it is proposed that there is link between music and early reading skill of pre-school children. However, the reliability of the test may bequestionable, because there were only sixteen children in the sample and only a limited number of musical skills were tested.

Anvari et al. (2002) have found that melody and chord discrimination correlate with phonemic awareness and reading. Forgeard et al. (2008) have come to the conclusion that children with dyslexia show deficits in melody discrimination.

According to Ziegler and Goswami (2005), three basic cognitive skills relate to word reading; phonological awareness, letter-speech sound processing and rapid automatized naming (RAN). Phonemic awareness refers to the ability to identify the sound components of a word. Research indicates that children with better phonemic awareness have advantages in learning to read. The formation of the phonological awareness contains: the perception of rhythm, syllable perception, and the awareness of the inner structure of the syllable. Rhythm perception effect the segmentation of syllables. Gósy (2000) has summarized the different approaches by saying that the two crucial factors are periodicity and structure which can be completed with sonority, the structure of the syllable, and accent. Surányi et al. (2009) have claimed that there are differences between the rhythm and accent perception of English and Hungarian children and assume that the language specification of certain acoustic features of rhythm and accent is of crucial importance.

In the development of phonological awareness the cerebral representation of syllables is essential. the cerebral representation of the syllable is formed by the children's own speech perception (Csépe, 2005). Rhymes, lullabies and children's songs are useful in developing syllabic awareness but they play a different role in English and Hungarian due to their distinct natures. The process of perception, syllabication and rhyme awareness develop in a different way with Hungarian-speaking children. Hungarian rhymes strengthen syllabification. The development of phonological and phoneme awareness, i.e. metalinguistic awareness, is closely linked to other cognitive functions, e.g. auditory attention, speech perception, memory, comparison and categorical skills.

Further linguistic factors are early phonological perception, which forms the basis of speech comprehension, and morphological awareness (Nielsen et al., 2011). Speech perception, which is a key factor to successful learning reading and writing (Gósy, 2005), is a popular field of research in Hungary. According to studies from the 1970s, the most important factor in learning to read is phonological awareness (Chafouleas et al., 1997). It can be the precondition of reading (Mann & Stoel-Gammon, 1996). However, in the 1980s, studies showed that phoneme awareness develops during the learning process of reading, so phonological awareness is not the precondition, but the consequence of reading. Now researchers agree that the development of phonological awareness is the precondition of the success of learning to read, while phoneme awareness, i.e. higher level of phonological awareness, matures completely during the learning process of reading (Loizou & Stuart, 2003). According to Plaza's research (2001) with French-speaking children, phonological awareness correlates with the success of learning to read and it is also a universal marker of the problems in reading.

2.3. Skill level of music readers

Reading comprehension means interactions between the characteristics of a given text and the reader's contribution to the reading situation. Proficient readers have relevant knowledge, word decoding ability, competency with a variety of reading strategies, metacognitive skills, etc. (Perfetti, 1985, p. 111). This is also true for music reading, where the text is the score.

By the age of seven, children are able to read complex rhythm patterns nearly as well as adult non-musicians (Drake, 1993). The music reading process is supported by the chunking process that allows students to organize and save a large pattern of vocabulary in memory. More skilled music readers use different strategies to prepare for a musical performance. For example, they read the score silently, check the key elements of the melody, or try to search for difficult passages within the piece prior to performing, whereas less skilled music readers do not apply such strategies (McPherson, 2005).

In silent music reading, the musician may not examine all the detailed information which the score contains. The visual processing is selective and guided by the requirements of the given task. Music reading comprehension can be influenced by the following factors: the choice of an appropriate reading technique, the difficulty level of the musical text, familiarity with the different text types, the microskills of reading comprehension, social factors and the medium of the text. The concept of silent reading can cover all types of inspections of music notation without performance requirements.

2.4. Metacognitive aspects of learning music

The term metacognition literally means cognition about cognition, or more informally, thinking about thinking. Flavell (1976) defined metacognition as knowledge about cognition and control of cognition. The knowledge component encompasses what one knows about cognition, including knowledge about oneself as a learner, about aspects of the task at hand, and about strategies needed to carry out the task effectively. Flavell (1976) recognized that metacognition consisted of both monitoring and regulation aspects. Metacognition refers to the active monitoring and consequent regulation and orchestration of these processes in relation to the cognitive objects or data on which they bear, usually in service of some concrete goal or objective. Metacognition means a higher-level thinking, within which mental activities can be actively influenced during the learning process, and also through the effectiveness of different learning strategies. Metacognitive thinking is an important part of learning; there is a correlation between the use of metacognitive skills and the academic performance of students.

Researchers found that the students' participation in any art program positively affects their cognitive and metacognitive skills. In Hollenbeck's research (2008), a small population of instrumentalist high-school students (N=48) were shown to be successful in other subjects, like mathematics, literature, foreign languages, or sciences. All of the students earned a B or a better grade in Maths, while 98% and 81% of the students earned at least a B in Science and in Foreign Languages, respectively. Broken down by skill groups, 58 % of cognitive skills, 70% of affective skills, and 71% of metacognitive skills were identified as being obtained by a majority of students.

Janurik (2008) has pointed out the correlation between the time students spend on learning time an instrument and academic achievement. Metacognitive knowledge and skills can be improved from the early years of formal education, and students are the most susceptible for the development of metacognition between 10-15 years of age. According to Pressley (2002), the characteristic of good readers is that they are active from when they begin of the reading until the end, which involves more decisions and consequences.

Although there is a great deal of evidence supporting the importance of reading strategies, there are only a few studies conducted in the field of music reading. Teaching reading strategies is also the task of solfege or music teachers. With their help, students can become successful music readers. Flavell (1979) proposed a formal model of metacognitive monitoring which includes four classes of phenomena and their relationships. The four classes are 1) metacognitive knowledge, 2) metacognitive experiences, 3) tasks and goals, and 4) strategies or actions. The strategies of metacognitive knowledge involve identifying goals and sub-goals and selecting cognitive processes. Flavell (1976) also emphasized that these types of variables overlap and that individual works overlap with combinations and interactions of the metacognitive knowledge.

In music, research tends to use music-text reading that refers to the importance of the musical material. Different musical texts need the use of different strategies which have not been identified yet. Reading strategies can be classified in the following three clusters of metacognition: planning, monitoring, and evaluating strategies (Israel, 2007; Pressley & Afflerbach, 1995). Planning strategies are used before reading. Activating learners' background knowledge to get them prepared for reading is an example of planning strategies (Almasi & Fullerton, 2012). Also, previewing a title, picture, illustration, heading, or subheading can help readers grasp the overview of the text. Readers may also preview the general information in the text and its structure (Paris, Wasik, & Turner, 1991). Learners may check whether their reading material has a certain text structure, such as cause and effect, question and answer, and compare and contrast. Furthermore, setting the purpose for reading can also be categorized as a planning strategy (Paris et al., 1991; Pressley, 2002). Monitoring strategies occur during reading. Some examples of monitoring strategies are comprehension of vocabulary, self-questioning (reflecting on whether they understood what they have read so far), summarizing, and inferring the main idea of each paragraph (Israel, 2007; Pressley, 2002). Evaluating strategies are employed after reading. For example, after reading a text, learners may think about how to apply what they have read in other situations. They may identify with the author, a narrative, or main character, and may have a better perspective of the situation in the book than they did at first. In summary, metacognitive reading strategies are classified into three groups of planning (pre-reading), monitoring (during reading), and evaluating (post-reading) strategies and each group has a variety of strategies that require readers' metacognitive processing.

2.5. The influence of text characteristics

Text characteristics have a great influence on reading and reading comprehension. In the present dissertation, I used Kodály's exercises, in which the different features and structures of the texts play an important role during the reading process. As only a few studies deal with text characteristics in music, it is essential to investigate them.

Explicit awareness about text structure and the expectations engendered by certain common features of text may be useful aids for readers, helping them to invoke relevant background information and schemas to facilitate their construction of meaning-based representation. Knowledge about the organization of narrative texts increases throughout middle childhood (Stein & Glenn, 1982), as does the ability to generate well-structured coherent stories. Perfetti (1994) proposes that a possible source of comprehension failure is inadequate knowledge about text structures and genres, which may arise because of insufficient reading experience. Instruction in expository text structure aids reading comprehension (p.51).

Children with specific comprehension difficulties demonstrate impairments in their ability to structure stories (Cain, 2003) and have impoverished knowledge about the information contained in certain features of text, such as titles (Cain, 1996). Comprehension arises from a series of cognitive processes and activities, including word decoding, lexical access, syntactic processing, inference generation, reading strategies (e.g., self-explanation) and post-reading activities (e.g. summarization, asking and answering questions, argumentation). These contribute to a reader's ability to connect the meaning of multiple sentences into a coherently connected mental representation of the overall meaning of text. Students read the text for different purposes which are closely associated with the text genre.

2.6. Eye movements in music reading

Using eye-tracking is becoming an increasingly popular methodological tool. Its methodology looks back on a long research tradition in text reading. Eye tracking offers an opportunity to facilitate and enhance the development of student's music reading. Eye movement in music reading means the scanning of a musical score by the musician's eyes. This occurs as the music is read during performance, although musicians sometimes scan music silently to study it.

Research suggests that the individual's musical skills significantly influence eye movements during music reading. The perception of visual information occurs almost entirely during fixations and little information is picked up during saccades, so fixation durations are considered to reflect the time and effort needed to process the fixated information. Skill improvement is also related to the gradual use of shorter fixation durations (e.g. Häikiö, Bertram, Hyönä, & Niemi, 2009; McConkie et al., 1991).

Previous research on eye-tracking has shown that experienced music readers read more units ahead. Their eyes fix on the structurally important functions, such as certain musical chords or phrases, and then they glide towards the less important musical details. Experienced music readers use shorter and fewer fixations to encode music notation because they can process more information during one fixation (Lehman & McArthur, 2002). Studies aim to find out which characteristics of music material could be the targets of fixations. Music readers do not fixate on all notes, but they fixate on blank areas between the notes. Goolsby (1994) claims that better music readers' fixations were also directed across phrase boundaries, while less skilled readers tend to focus on individual notes. Eye-movement analysis has discovered that fixations become shorter if the reader is familiar with the musical structure of elements, because part of the information is already known (Lehmann & McArthur, p.135). Fixations appear to target spaces, note stems or note tails and they follow the melodic contour. The eyes usually look for where the highest or lowest notes of the melody are located. According to Truitt et al. (1997), bar lines are scarcely fixated. This suggests that the fixations are not randomly targeting any one symbol on the musical score, but in general, fixation does not precisely target the note symbols, but rather the area around them.

In recent decades, an increasing amount of research targeted the process of reading about the span or the area from which readers obtain information. The term *perceptual span* means the span of the effective stimulus or the amount of textual material processed within one fixation. The perceptual span for skilled readers of alphabetic writing systems consists of 3-4 letters to the left of fixation (or the beginning of the currently fixated word) and 14-15 letter spaces, five to seven words to the right of fixation (Rayner, 1978). Sloboda (1974) proposes that eye-voice span in reading research could be named as eye-hand span in instrumental music reading. During music reading, it is normally five to seven notes, but the distance can be larger (two bars) (Sloboda, 1984). The average time length of the span between the gaze and musical performance is typically around one second (Furneaux & Land, 1999; Wurtz, Müeri, & Wiesendanger, 2009), though slower performance tempo may increase the length of the span (Furneaux & Land, 1999). Sloboda (1984) concludes that eye-voice spans are not fixed, and fixations are not restricted to a limited time span, but they grow and shrink according to the musical structure. The eye-voice or eye-hand span in music ends to coincide with phrase boundaries, which show higher level expectations about end phrases.

Students tend to focus on the white space between the notes, i.e. the intervals, so relatio is important. (Goolsby, 1994 and Rayner, 1978). This means that prior knowledge about intervals, triads and their important factors of music theory facilitates their recognition – visually, kinesthetically, and aurally. The music reading process itself deals with simultaneous integrated processing. The language processing system gives commands to move the eyes as it is engaged in semantic and syntactic analysis of the musical text being read. In music reading, general information is being extracted during the initial portion of the fixation (Zola, 1984).

Most eye-movement studies focus on instrumentalists, e.g. pianists, violin or guitar players. Fewer studies examine singers and none of them explore a specific music method. Most research with eye movement in music reading was primarily aimed to compare the eye movement patterns of skilled and unskilled performers, generally adults. Music studies have been usually conducted with a few participants; e.g. four in Kinsler and Carpenter (1995); seven or eight in Furneaux and Land (1999), Truitt et al. (1997), and Wurtz et al. (2009); 25 in Drai-Zerbid et al. (2011). Participants of prior studies have been typically divided into 2–3 skill-based groups (Penttinen, 2012). Music skills have been defined in various ways in eye-tracking studies. Group division can be based on the participants' music reading skills, performance ability or general musical experience.

In research with eye-tracking on musical skills, correlation was found between rhythmic reading skills and musical performance skills (Drake, 1998). Correlation exists between reading of notes and reading of rhythm, and between reading abilities and the results of standardized music tests (Elliott, 1982). Luce (1965) found correlations between music reading abilities and the results of musical memory, IQ tests, reading and mathematical tests.

2.7. Functional music literacy

In terms of development, literacy is similar to expertise: it is cumulative, and its learning is not tied to age (Csapó, 2004). Music literacy is traditionally defined as an acquired musical knowledge and a skill to translate notation into vocal sound (reading/singing) and sound into notation (notating/ writing). Both reading and notating skills are fundamental prerequisites for comprehensive musicianship. However, the term *literacy* is continually changing and evolving, and we cannot narrow its meaning to this simple definition. Furthermore, it is important to take into consideration the new ways and forms of communication, the nature and speed of information, and the growing role of technology. Music reading is a highly complex activity on multiple levels, and the acquisition of reading literacy means to learn, use and perfect a corresponding set of highly interrelated operations, skills, and strategies which can and should be improved until adulthood even in the case of highly skilled students (Schnotz & Molnár, 2012).

The term *functional music literacy* was defined by Jorgensen (1981). It means the minimal level of musical skills which enables students to function with musical materials. Functional reading literacy is generally seen as an enculturation process where literacy practices at school are designed so that they resemble literacy events, practices, and authentic texts used for specific purposes in real-life contexts, emphasizing social interaction and collaborative construction of meaning (Linnakayla, 2007). One of the principal aims of music education is to develop a functional musical literacy through solo or group (choir, chamber, or orchestra) performances. However, music reading achievement is usually weak, only a few music programs address reading skills beyond the most perfunctory level (Ester, 2001).

Functional music literacy includes meaningful listening to music and allows students to enjoy music and active music making through contributing to the development of their musical taste. Through culturally relevant and authentic activities that could be partly in the hands of public schools, it fosters the acquisition of musical reading and musicianship, nurturing the development of musicians, in addition to the development of future audiences.

3. Music literacy instruction

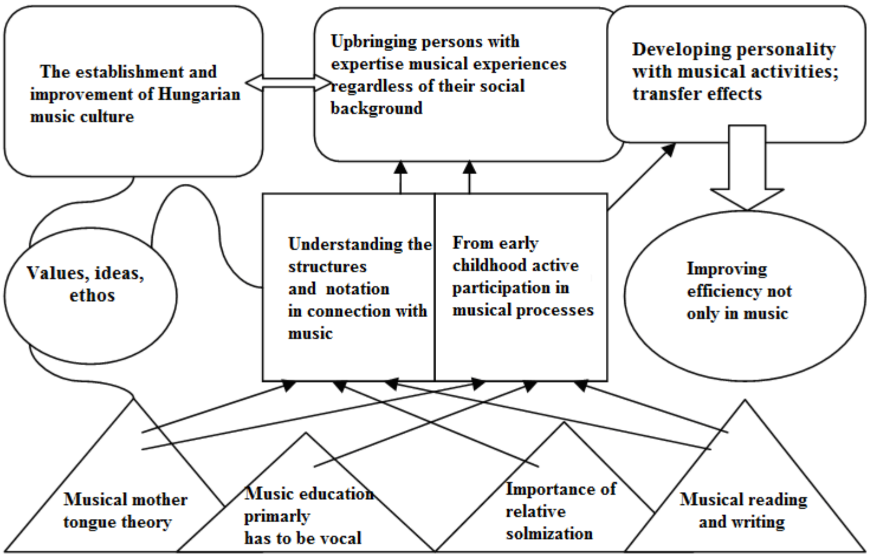
The school music curricula of schools in Hungary are based on the principles of Zoltán Kodály. The Kodály concept is basically vocal centered, and choral singing has a major role. The chapter includes detailed information about the compositions of Zoltán Kodály – from the 333 Reading Exercises to the volume of Epigrams. They will be discussed in detail below as well as music curricula in mainstream and music schools.

3.1. Kodály's music pedagogical concept

Zoltán Kodály's principles in music education have a major international influence across the world. He is universally recognized as one of the greatest figures in music teaching. The Hungarian music education from kindergartens to universities is also based on Kodály's concept. His pedagogical ideas were built into the school curricula and set out in textbooks for music and singing. According to his concept, musical training should be an integral part of the general curriculum and music should not only be accessible to the elite, but for everyone.

Gönczy (2009) created the hierarchical illustration of the main elements of Kodály concept following Ittzés, who highlighted four principles (2004) which define the essence of Kodály's ideas: 1) all children should receive music education; 2) the bases of the music education are the human voice and singing; 3) meeting with music should take place in respect of the principles of value-orientation, and the musical mother tongue provides the guarantee for this; 4) the prerequisite of educating music experts is the acquisition of musical literacy (music reading and writing) with the use the relative solmization. The application of the relative sol-fa syllables can serve as a memory aid for reading pitch. The listed principles can be interpreted in several categories, and with each other in a hierarchical relationship. Figure 3 presents this model.

Fig. 3 The hierarchical illustration of the main elements of the Kodály Concept (Gönczy, 2009, p.172.)



According to Ester (2010), solmization is not only the most ancient form of teaching the pitch dimension of vocal music, but is now also the most widely used form of music pedagogy. In all adaptations two basic tendencies can be distinguished:

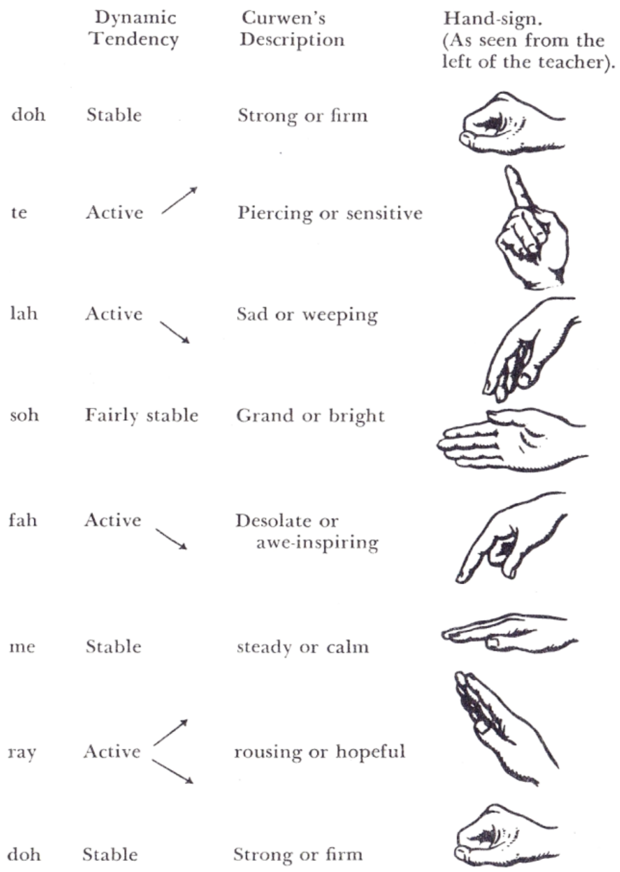
1. Syllables to indicate the absolute pitch of the sounds.
2. Syllables to indicate the relationship between the sounds.

Kodály became interested in relative solmization around the 1930s Sarah Glover's (1786-1867) Tonic-Solfa system was adapted by John Curwen (1816-1880). Curwen published a number of textbooks and songbooks including *The Standard Course of Lessons on the Tonic Sol-fa Method of Teaching to Sing* (1858). In the 1872 edition of *The Standard Course*, Curwen excluded the staff system of notation from the Tonic sol-fa course, relying solely on his own invented notational system in the publication of textbooks, vocal music and even instrumental music.

Kodály discovered that relative solmization could make an excellent tool for achieving his educational goals; *music literacy*, in the training of school children as it was achieved in Britain in the 1930s (Nemes, 2001, p. 197). Teaching experience shows that singing with sol-fa syllables facilitates the rapid and secure development of important musical skills, such as singing, intonation and music reading. However, empirical studies on sol-fa syllables have not yet been conducted. Hand signs are often used in connection with sol-fa singing. They give character to each sound, show their spatial relationships, and help to acquire a clear concept of the sounds and the intervals. Hand signs, borrowed from the method of Curwen, are performed during singing exercises to provide a visual aid. This technique assigns to each scale degree a hand sign that shows its particular tonal function. For example, *do*, *mi*, and *so* are stable in appearance, whereas *fa* and *ti* point in the direction of *mi* and *do*, respectively. Likewise, the hand sign for *re* suggests motion to *do*, and that of *la* to *so*.

Kodály added upward/downward movements to Curwen's hand signs, allowing children to actually see the height or depth of the pitch (Wheeler, 1985). The signs are made in front of the body, with *do* falling about at waist level and *la* at eye level. Their distance in space corresponds with the size of the interval they represent (Choksy, 1999). Hungarian music text books include hand signs from the first to the fourth grades. In our research students' reading of the hand signs is also examined. Figure 4 presents the hand signs and the corresponding characters.

Fig. 4 Hand signs (Simpson, 1976, p. 111)



Kodály emphasized the significance of the pentatonic in the acquisition of a musical mother tongue for Hungarian music teachers and children alike. He stated that pentatonic is not only a segment but the central core of Hungarian folk music. Many of Kodály’s children’s choruses are based on Hungarian folk songs. In Hungarian music education, folk songs are given an outstanding role. A series of important musical phenomenon, e.g. forms, scales, intervals can be learnt from folk music. Folk songs can be read with text or with sol-fa. Many songs are richly decorated, while higher level students also read decorations.

3.2. Kodály’s singing and reading exercises

Zoltán Kodály’s reading exercises form the basis of my eye-tracking studies. He composed reading and singing exercises from primary to professional levels. Kodály as a composer characterized his own life-work as human voice centered music. He declared that the question of music education (including the writing of pedagogical pieces) was more important for him than composing larger symphonic works (Ittzés, 2006). He claimed that music reading and writing can be learnt by anyone. In Hungarian music education solfege lessons are primarily built on the pedagogical compositions of Kodály. These works not only improve music reading and writing, musical memory or intonation, but they introduce students to the common musical activities, to the group or choir singing via a valuable music material. The metrical richness and variability is a characteristic of Kodály’s reading material (Hegyi, 1984).

The book entitled *333 Elementary Reading Exercises* (1943), has an original title of Introduction to Hungarian Folk Music. The book contains Kodály’s own unison melodies from the two-note material, d-r steps to the whole anhemitonic pentatonity. The tunes are related to Hungarian folk-music, but show several Western music characteristics (e.g. periodic structure.) The aim of the booklet is to establish music reading skills via sol-fa notation and the practicing of simple rhythm patterns (Ittzés, 2006).

In Pentatonic music volumes I-IV, Zoltán Kodály uses not only the Hungarian folk music, but also other Finno-Ugric peoples’ folk tunes. The four volumes comprise a total of 440 pentatonic melodies. The first and the third volume contain a hundred Hungarian or Mari melodis, the fourth contains 140 Chuvash folk songs. The second volume of 100 Little Marches (1947) contains Kodály's own compositions. Elementary school students can perform the exercises by voice or by xylophone (or by any other available instrument). No texts belong to the music reading exercises. All of the four booklets are published with sol-fa notation to practice the pentatony in more detail.

Kodály's Biciniae Hungarica Volumes I-IV aim to introduce two-part singing. 480 bicinia are in the four volumes (1947). The first three songs are polyphonic arrangements of the Hungarian folksongs, the third volume contains historical songs. The fourth volume contains 57 Mari– and three Finnish folk songs. The Bicinia Hungarica represent an independent style and, illustrate the pentatonic polyphony of Palestrina's art. Although Kodály claimed the volumes were not intended for public performance, most bicinia can be performed in concerts.

Kodály's two part reading exercises appeared from the 1950s in several series, entitled 77, 66, 55, 44, 33 and 22 two-part exercises and also Tricinia, which includes 29 three-part singing practices. The 15 two-part singing exercises (1941b) was intended to transit from folk song based pentatonic style to Baroque, namely Bertalotti's solfeggi. Polyphony, as well as different kinds of imitational structures and modulations exist in the exercises. Unlike Bertalotti, Kodály uses only the treble clef. The booklet contains reading exercises which progress from easy to more difficult levels (Ittzés, 2006).

3.3. The content of music school curricula in Hungary

The input of the educational content is regulated by curricular and content-related aspects of assessment frameworks have to be in line with the curriculum. While compiling the test battery, I took into consideration the curricular regulations. According to the 2011 curriculum, the aim of the Hungarian music schools is to develop artistic skills and prepare students for further music education. The developmental objectives of music education are as follows:

- the acquisition of music reading and writing
- the harmony of melody-text-performance
- familiarity with the characteristics of musical genres and styles
- learning music history (periods, genres and composers)
- performing one- or multiple-part compositions with instruments or by singing
- familiarity with musical instruments
- encouragement of concert attendance

From 2001 on, framework curricula have been functioning as intermediate regulators between the core curriculum and local curricula. Instead of cultural domains and educational phases, they define developmental tasks by academic subject and grade. Systems of music-school education include the subject of solfege. According to the frame curriculum, the objectives of solfege are to develop students' musical skills and extend their knowledge in the following fields:

- moral and intellectual shaping of the students' personality
- founding of national identity by students
- developing music literacy
- promoting instrumental learning
- developing the following musical skills: rhythmic skills, stable intonation, orientation in the vertical dimension (e.g. intervals), melodic and harmonic skills, music reading and writing, musical structures and forms, musical memory, developing creativity, improvisation, and music listening skills

The musical activities mentioned above deepen the understanding of musical concepts, theoretical and formal principles, while influencing aesthetic and affective musical formation through techniques of vocal breathing and performance and the evaluation of musical interpretations. Musical activity encourages the creative use of musical elements. The final result of creation of musical content is evident in the music notation of particular creations. Collaborative creation of musical contents indicates a strong level of development in musical and formal-musical thinking, therby further enhancing functional musical literacy (Zadnik, 2012).

The music program of music schools includes a music preparatory program for six-year-olds and solfege from the age of seven. Practice shows that usually pupils in the music preparatory courses are usually gradually introduced to standard music notation. In addition to solfege, students have individual instrumental classes (pupils have thirty-minute individual instrument classes twice a week). Pupils starts to become involved with standard music notation in the first grade of solfege at the age of seven, when they have acquired many musical experiences and images. During this period, the pupil gets to know standard music notation, with its visual symbols.

Students have a thirty-minute-long solfege lesson twice a week at the music preparatory level. In addition to solfege, students go to individual instrumental classes: in the first cycle pupils have thirty-minute-long individual instrument classes twice a week, whereas in a higher ability level they have forty-five-minute-long instrument classes twice a week. Solfege is compulsory in the first four years, then students can choose from solfege, music history, or chamber music. Today, about a millennium after Guido's revolutionary approach, solfege has mutated into a powerful tool for music reading literacy. However, it is also contested for being too rigid and old-fashioned in comparison to electronic musical learning facilities and that, as an educational concept, it does not fit the twenty-first century (Sagrillo, 2016).

3.4. The National Core Curriculum requirements for music education in primary schools

Music is an important element of the school curriculum. The main objectives of music education are to introduce children to the joy of singing and playing music, as well to provide keys to give them knowledge of musical experience, understanding and enjoyment. The school of music pedagogy is based on the principles of Zoltán Kodály, centered on active singing and music making, and based on traditional folk music and valued compositions. The development occurs with the use of relative solmization.

Through the material in the curriculum, students learn about other nations' music and folk music, national music culture, classical music, jazz and pop genres. School musical experiences encourage students to actively participate in choirs or domestic music-making. Concert pedagogy also forms a part of mainstream school education (NCC, 2012).

The developmental objectives of music lessons are the following, discussed in turn below.

1. Musical reproduction:
   - singing
   - generative and creative (individual and group) musical activities
   - music reading
2. Musical reception
   - developing receptive skills
   - music listening

Music reading is the tool of musical comprehension. Its code system can help students to orient themselves in the content of music. Music reading, itself, is not a goal, but it is an effective means of learning music. The musical turns of folk songs, used in the recognition of rhythmic, melodic and metrical elements, and in understanding and analyzing their form, can help in the development of the awareness of form. Instead of choosing an analytical approach to style-definition, teachers should find a life situation, an emotional expression or personal connections with aesthetic beauty. The interpretation of the texts of folk songs highlights the rich symbolism of Hungarian musical-vocabulary.

Framework curriculum defines the requirements of music theory by grades. In the field of rhythm-reading in the first grade, students learn about the following rhythm values: quarter note, eighth note, quarter rest, bar line, double bar line, repeat sign and 2/4 time signature. In the second grade: half note and half rest; in the third grade: individual eighth note, eighth rest, syncopation, whole rest and 4/4 time signature and in the fourth class: dotted half note, ¾ time signature, dotted rhythm, inverted dotting/ Lombard rhythm and the ostinato.

In the field of melody-reading students study about the sol-fa names and handsigns. They also learn about the two-bar motifs, musical questions and answers, the canon and the melodic ostinato. Students learn about dynamic signs in the fourth grade, i.e.: crescendo and decrescendo signs, piano, mezzoforte and forte signs and concepts. They also learn about the following musical instruments: recorder, piano, violin, violoncello, flute, oboe, clarinet, bassoon, horn, timpani, metallofon and the different types of voices of choirs, i.e. soprano, alto, tenor and base, and also about the choirs: children, female, male and mixed choirs. String orchestra, wind orchestra and symphonic orchestra are also parts of the music curriculum of grade 1-4.

The objectives for 5th-8th grade pupils are to deepen the experience and knowledge gained previously, and to develop them via singing and learning music terminology (musical skills, forms, signs for tempo and dynamics, and intervals) in addition to and music history (periods, outstanding composers, styles and genres). The national core curriculum promotes more frequent concert attendance and focuses on developing music reading, musical memory, polyphonic singing and applying ICT tools.

The music material for 5th-8th graders is based on Hungarian folk songs and the characteristics of music styles and history. Regarding music reading in the fifth grade, students learn r' and m', the absolute system with each absolute name in C-major, the perfect intervals, the pentatonic scale, and the major and the minor scales. In the sixth grade, pupils learn about the minor and major seconds and thirds, while they study about major and minor sixth and seventh in the seventh grades. In the eighth grade the focus is on the contemporary music styles. Students have one music lesson a week in the upper grades, which does not seem to be enough in the field of music reading.

Teachers evaluated music, either through out-loud or silent reading of textbook passages, is primarily informed by their own experiences in solfege or music lessons. Basically, standardized music reading tests have not yet been available in Hungary. Aditionally, no comprehensive assessment standards for reading are available as yet. The curriculum does not mention the roles of metacognition and reading strategies, as these concepts are still unexplored.

3.4. Assessing music reading in Luxembourg

Luxembourg plays a leading role in European music education, especially in solfege (Buzás, 2014). This was the primary reason why this country was chosen for the place of my research, which was conducted in specialized music schools for examining students' reading skills. In 2012, 85,000 pupils received general education (primary and secondary schools) in Luxembourg; 17.3% of them attending music schools. This number is twice as high as in Hungary (Sagrillo, 2012). Music school pupils attend compulsory 45-minute solfege courses twice a week, just as they do in Hungary.

The assessment of reading skills is of crucial importance in Luxembourg. At the end of each school year, all students from music schools and conservatories are required to take written and oral exams in solfege and music theory, compiled by the Association des Ecoles de Musique du Grand-Duché de Luxembourg (hereafter UGDA). UGDA (Union Grand-Duc Adolphe) is the umbrella organization of music in Luxembourg, representing choral societies, brass bands, music schools, theatrical societies, folklore associations and instrumental groups. Covering some 340 associations, it has over 17,000 individual members. The music test material, developed by UGDA, measures the reading performance and theoretical knowledge of six grades in music schools. These written and oral materials typically contain instructions in three languages, in French, German and Luxembourger. The tests include music dictations, listening, reading and theoretical exercises in various forms. The level of this music examination is much higher than in Hungarian music schools in each grade. The students have to take sight reading tests with complex rhythm and melodic patterns (Figure 5). They have three minutes to read the score silently, then they sing and conduct the reading exercise after 10 minutes of practice. They perform the composition with piano accompaniment. The music material contains a variety of C-clefs and combinations of different metrums. So students need to transpose the text. The music reading text contains a rhythm reading exercise with piano accompaniment. This rhythm task is performed with sticks. In addition, choir singing is included in the assessment. In Hungary, no such assessment system for testing students' reading skills has been introduced.

Fig. 5 Luxembourger rhythm reading example for music school students (Buzás, 2015, p. 131)

4. The concept of the empirical studies

When discussing the theoretical background, I took into account the factors that are related to music reading and are associated with reading acquisition. My studies were the first attempts to examine students' music reading skills with the help of the latest digital technologies in Hungary and in Luxembourg. My research questions originated in every day school practice in general and specialized music education. According to the objectives of music curricula, students become familiar with the basic music notation system and musical symbols by the age of 10. In my studies, I investigated procedures that encompass a broad spectrum of the components of music literacy. No complex assessment of music reading skills is used in Hungary. Internationally, musical tests assess mainly aural skills. Due to the lack of music reading tests, my basic goal was to analyze and test music reading skills of students via technology-based assessment. Music reading was investigated with eye movement technology while students were presented with Kodály's reading exercises. I conducted three empirical researches with eye tracking. The use of this methodology allowed the recording of the music readers' eye movements with extreme precision. This technology enables us to learn more about the development of students' cognitive, learning, reading and, information processing skills; however, the number of subjects is limited due to the time requirements research process. In order to test a larger sample I developed and tested two online music reading test versions for mainstream and music school students. I used the eDia online assessment platform where students' rhythmic and melody reading skills were tested. The tasks can be done in any order, and changes can be made any time before the end of the test. After the test respondents were asked to fill in a background questionnaire so that the relationship between music reading skills and several background variables could be explored.

4.1. Research questions

1. What is the level of 10-14 year old students' music reading skills?
2. How can musical structure influence students' music reading skills?
3. How is eye fixation related to music reading skills?
4. Do students use strategies during music reading?
5. How can different music education methods affect music reading skills?
6. Is gender a factor in the performance of the music reading test?

7. Can online testing of music reading skills be implemented in general school settings?

8. How reliably does the online music reading instrument assess music reading skills?

9. How can the measured skill structure be characterized?

10. What is the relationship between the students' achievement in music reading and the background variables?

11. Do visual-spatial skills correlate with music reading skills?

12. What are the differences between the results of students in different school types?

4.2. Hypotheses

The hypotheses are summarized in Table 5.

Table 5 Research hypotheses

Hypotheses	*Concerned measurements*				
	Study 1 eye - tracking	Study 2 eye-tracking	Study 3 eye-tracking	Study 4 Study 5 eDia	Study 6 Study 7 eDia
1. Level of music reading skills of students can be analyzed by the tests.	X	X	X	X	X
2. Music structure can have an effect on students' music reading skills.					
Pattern recognition helps with the process of music reading.	X	X	X		
Period-like music structure enhances and facilitates music reading.	X	X	X		
Eye-movements are influenced by text characteristics.	X		X		
3. Fixation/ music perception are related to the music reading process.	X	X	X		
Fixation occurs in the middle of the bars.	X	X	X		
Most fixations occur at the beginning of the musical material.	X	X	X		
4. Music reading strategies can be analyzed.	X		X		
5. Music education methods do not lead to different music reading processes.			X		
6. There is a difference between the results of girls and boys in favor of the girls.		X	X		X
7. Online testing of music reading skills can be implemented in general school settings.				X	X
8. The online music reading test is reliable and it is an appropriate tool for measuring music reading skills.				X	X
9. Music reading skills are related to each other. The measured skill structure is homogeneous.				X	X
10. Music reading achievement is influenced by a positive attitude towards music lessons.				X	X
11. Visual/spatial skills correlate with music reading skills				X	X
12. There are differences in music reading skills between different types of school				X	X

4.3. The research process

Although aural skills and music perception are often investigated by researchers in Hungary and abroad, there are no relevant studies on music reading among upper-primary school students. In our empirical research we conducted three eye-tracking studies which were followed by cross sectional online measurements between 2013 and 2016. In the eye tracking studies students' silent and loud rhythmic and melody reading skills were examined. It is the first time internationally when reading skills are explored with Kodály's music reading exercises. I was interested whether the structural and stylistic characteristics of Kodály's compositions influence students' music reading. I hyphotized, that pattern recognition and period-like music structure facilitate reading skills. Eye-movements characteristics indicate students' skill level. In the first assessment of students had to read different musical texts composed by Zoltán Kodály. In the second eye tracking research primary school students' rhythmic reading skills were analyzed using one of Kodály's *333 Reading Exercises*. I hypothesed, that different music education methods do not lead to different music reading processes. In the third eye tracking measurement students' reading skills from different European countries were tested and the influences of music teaching methods (Dalcrose / Kodály) in Hungary and in Luxembourg were compared.

After the eye tracking studies online music reading assessments were conducted among 10-14 year old students. These online assessments were based on the findings of the previous eye tracking research. The aims of the online research were to develop and test an online test battery for music reading and also to examine the results in order to present an overview of students' music reading skills. In our online studies we tested the music reading skills of students who are specialized in music and also those of mainstream school students. Two online music test versions were developed on the eDia platform to assess students' music reading performances. The first test version contained 55 tasks for music students and the second version contained 35 tasks for general school students. Both test versions contains a background questionnaire. With the use of online tests differences between these two types of school were identified. Altogether seven studies were conducted in Hungary, Germany and Luxembourg and data of 1071 students were analyzed. Our studies are summarized in Table 6, which shows the different stages.

Table 6 Summary of the studies

Research stages	*Date*	*Country*	*Type of school*	*N*
Eye tracking				
Study 1	February 2013	Hungary	conservatory	7
Study 2	March 2014	Hungary	mainstream school	18
Study 3	February 2015	Hungary	music school	18
		Luxembourg	music school	19
		Germany	music school	16
Online assessments in music schools				
Study 4	Fall 2015	Hungary	music school	74
Study 5	Fall 2015	Hungary	music school	160
Online assessments in mainstream schools				
Study 6	January 2016	Hungary	mainstream school	107
Study 7	February 2016	Hungary	mainstream school	651
Total				1071

5. Testing music reading skills with eye tracking analysis

Our research studies on music reading were informed by Erősné's *Model of Basic Musical Skills* (1992), the requirements of solfege and music education of in the Hungarian National Core Curriculum and the principles of the Kodály concept. Relevant reading reseach with eye-tracking methodology also served as an important source of my studies. Kodály's music reading exercises formed the basis for testing students' reading skills my eye-tracking research.

5.1. Study 1. Testing conservatory students' music reading skills

This study investigated skilled music readers' silent and loud reading on different Kodály compositions. The reading exercises used different notation systems, such as sol-fa-, stick- or staff notation. The participants study at a conservatory, where they study solfege two times in a week. Their level of music reading skills and performances are examined to answer the following research questions.

1. Where does music perception/ fixation occur during music reading on the text types?
2. How do different music text and structures influence students' perception?
3. Do students use strategies during music reading?

5.1.1. Methods

5.1.1.1. Participants

The research data were collected from seven female singer students, between the ages of 14-18 from a conservatory in Hungary. The participants have two 45-minute solfege lessons in a weak in addition to other individual and group music lessons. One participant has absolute hearing.

5.1.1.2. Apparatus

Eye movements were recorded by a Tobii 1750 Eye Tracker with Tobii Studio 2.2.7. software, manufactured by Tobii Technology AB (Stockholm, Sweden). The infrared cameras tracing the position of the participants were integrated into the body of the same computer monitor from which the stimuli were presented. Both eyes were tracked with a frame rate of 50 Hz, and the accuracy of the recording system was 0.5 degrees. Eye movements were recorded with a camera positioned directly in front of a computer screen. The camera was positioned approximately 55 cm from the participants' eyes. The eye movement tracking device made video and audio recordings, as well.

5.1.1.3. Stimulus materials

Students received four complex music reading exercises. The first eight-bar, period-like example is composed with sol-fa syllables, letter notation with changing meters, from Kodály's Pentatonic Music, Volume IV (Figure 6).

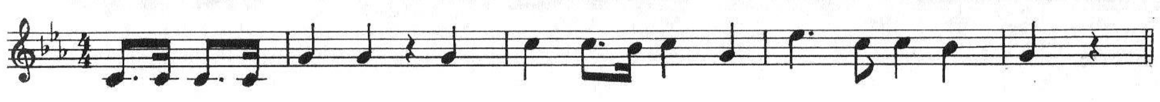
Fig. 6 Exercise 59. Zoltán Kodály: Pentatonic Music, Volume IV. (1962, p.19)

The use of different keys as a tool of transposition is an important part of solfege education. The second composition is composed in C-clef and with more complex rhythms and intervals (Figure 7).

Fig. 7 Exercise for transposing a song (Szőnyi, 1954, p.18)

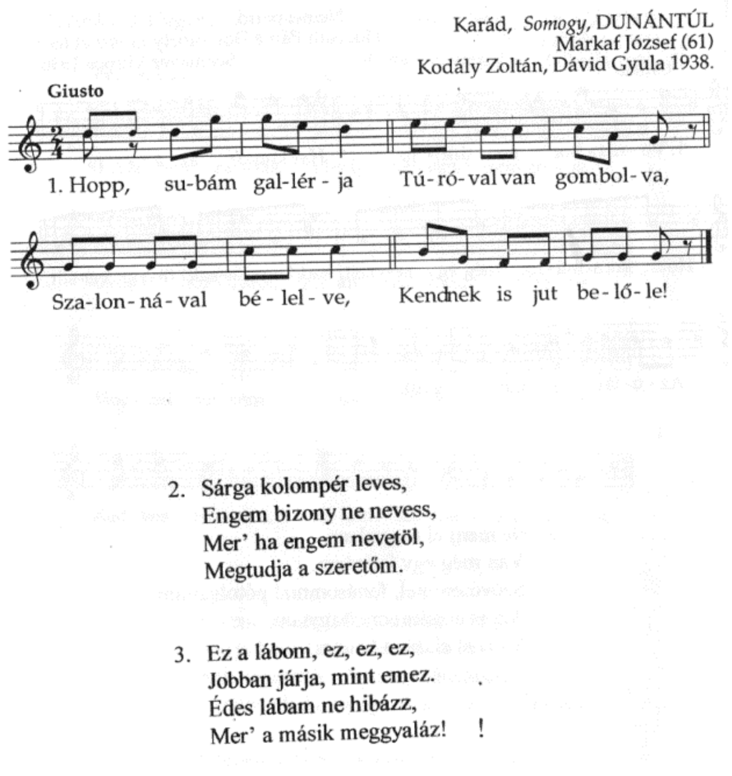
The next reading task was the initial bars of Kodály's composition for mixed choir entitled *Jesus and the Traders.* The four-bar pentatonic sample consists perfect intervals, such as unison, perfect fifth, perfect fourth starting with a half-bar long upbeat (Figure 8).

Fig. 8 Zoltán Kodály: Jesus and the Traders - excerpt (Kodály, 1963, p.87)



Folksongs are typical in every Hungarian textbook from the first grades in mainstream and in specialized music education. The last reading task for the students was a Hungarian folk song with three verses collected by Zoltán Kodály (Figure 9).

Fig. 9 Music score of the Hungarian folk song collected by Zoltán Kodály (Bodza & Vakler, 1999, p.8)



5.1.1.4. Procedure

To answer the research questions above we used eye-tracking methodology that can provide an objective source of evaluation. Eye tracking was conducted by two examiners trained in eye-tracking procedures. One of the examiners explained the testing procedures while the other examiner adjusted the camera and made sure that computer settings met threshold requirements. This was followed by the calibration and the validation process using a 9-point grid. Then the participants were asked to read several music reading exercises silently. After studying the musical score on the computer screen for one minute, students sang the musical exercises. There was no time limit for singing each exercise. Sessions lasted for approximately 15-20 minutes. Participants were given short breaks between readings when they looked tired.

5.1.2. Results

A number of conclusions in connection with music reading can be drawn on the basis of the thermal images of the eye movement tool. The eye fixates for the longest period in the beginning of the music score, examining the meter and the different key signatures, and also fixates on the more complex rhythms and intervals. On the thermal images the parts where the eyes fixate the longest, highlighted in red. The areas where students looked rarely are shown in green. The importance of this research is that those areas in different music materials could be discoverable where students have difficulties during music reading.

5.1.2.1. Letter notation

On the music score with sol-fa syllables, it can be observed that students became better and more confident in singing as they were getting familiar with the music material. They have fewer fixations towards the end of the score. Generally, students spent more observing the sol-fa notation, than the rhythm or stick notation. However, they fixated longer time if the rhythms became more sophisticated. Students rarely looked at barlines, they tended to focus in the middle of bars. The changing time signatures (6/8 and 5/8) are focused on bars 4. and 5., but not in the last bar where the first 6/8 bar is repeated with a perfect fifth below. The reason could be that the music structure is similar to an old-style folk song, and if students are familiar with folksong characteristics, they need less time for music reading (Figure 10).

Fig. 10 Thermographic picture of the letter-notated musical score

5.1.2.2. Melody in C-clef

The similar process can be observed in the musical example composed in C-clef. Students were learning the rhythms and tonality and they needed less effort towards the end of the composition. We can see in the task with C-clef that the difficulty means for the students in the 8th bar is not the intervals, but that after a long, sustained tone they should go on further with precise rhythms (Figure 11).

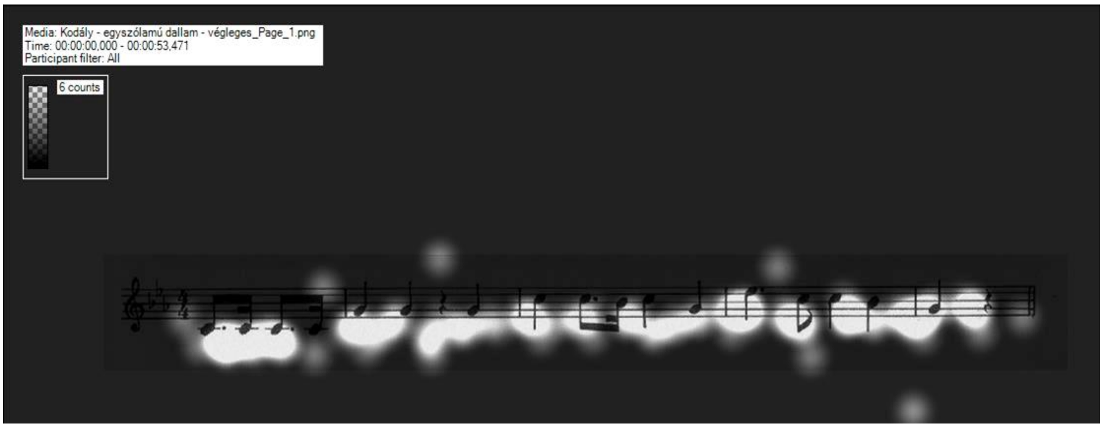
Fig. 11 Thermographic picture of the musical score in C-clef

5.1.2.3. Gaze opacity map of Kodály's compositions

On a gaze opacity map only those areas that got attention are shown and the ignored areas are blacked out, they are not observable. New information is revealed by the help of gaze opacity heat map pictures, we can observe clearly how rare students fixate on the stams of different rhythms. It is useful to compare the pictures of the two notation systems; while conservatory students focused only the sol-fa letter names on the first picture (Figure 12), similarly they focused more on the head of notes under the third line of Kodály's melody (Figure 13). It suggests that on a professional level to read music occurs mainly on the tones, not on rhythmic patterns. The spatial location of sounds alludes their rhythm. The automatization of music reading helps students to enhance their performance.

Fig. 12 Gaze opacity heat map of the musical score in letter notation

Fig. 13 Gaze opacity heat map of Kodály's Jesus and the Traders

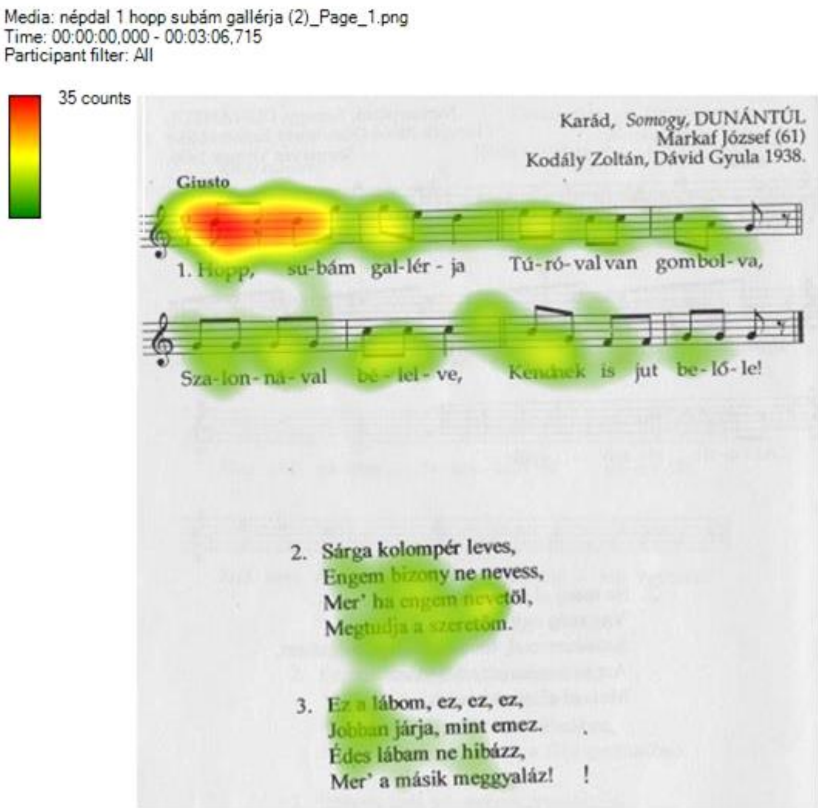


5.1.2.4. Folk song reading

The Hungarian folk song with three verses offered us a gripping result. Students used different music reading strategies to perform the song. The video recordings revealed that in the given one minute for silent reading, conservatory students tended to memorize the melody of folk song, and they rarely glanced back from the verses to the notes. They were singing the example only with a few mistakes. They learned the structure and familiarized with the tonality. However, they had difficulties with some strange words; it seemed that the folk text was even more difficult for the students, than the music notation itself.

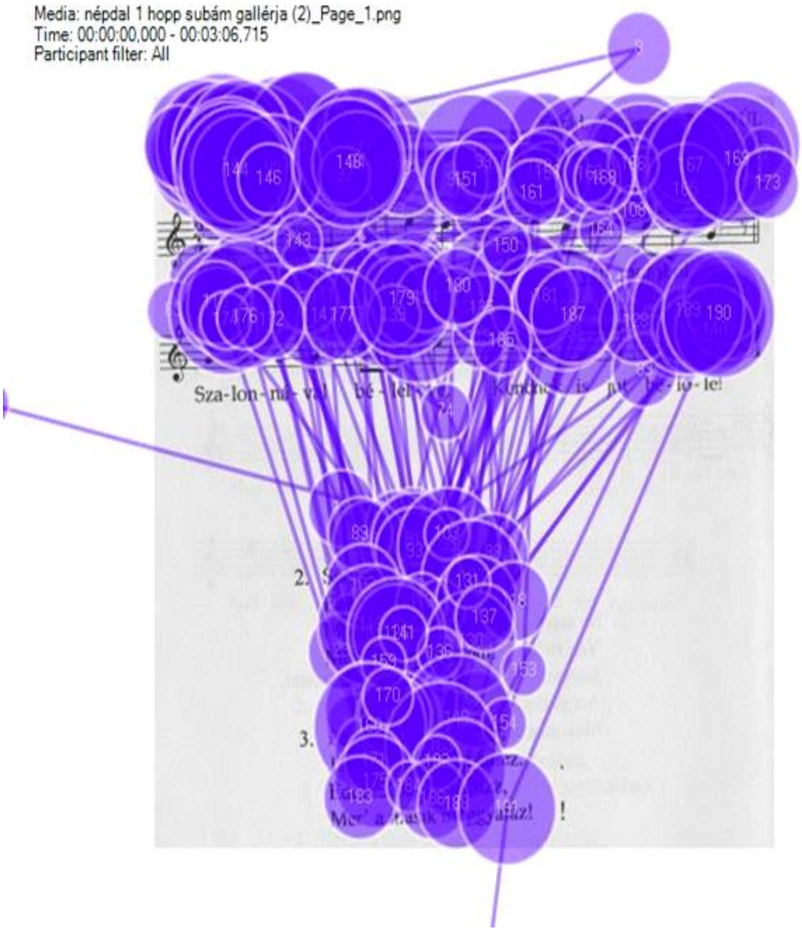
The thermographic picture of all students reveals that they focused the most on the first bar of the musical score here as well. In word reading the first and last fixations of each line in a text are generally longer (Rayner, 1978). It is often experienced that while reading a text difference grows line to line, maybe because the reader can process the text better and faster. We can observe a V-shaped pattern not only on the musical score but also on the verses of the folksong similar to reading (Figure 14).

Fig. 14 Thermographic picture of the Hungarian folk song



We can also enumerate the number of fixations of students during the music reading process (Figure 15). The control of eye movements during reading can be considered to involve in temporal and spatial decisions. There are a close relationship between these decisions, such as when processing difficulties occur, reading is slowed both by shortening saccades and by extending the fixation periods, resulting in an autocorrelation between fixation durations and saccade lengths (McConkie et al., 1979). In reading, and in most other visual tasks, a person makes several fixations per second, with each fixation providing a view, how the mind integrates information from the successive fixations. Thus, in several important ways, eye movement records can provide useful data in the study of cognitive processes in music reading as well.

Fig. 15 Fixation counts of the Hungarian folksong



On the basis of the number of fixations we can summarize the means of total fixation durations. The whole musical score, the folksong with text perceived in 122.52s. The mean of the musical score with the first text is 95.85s, the first verse's mean is 13.85s, the second verse has got the lowest mean (12.39s).

5.1.3. Summary

It was observed in each example that most of the participants were focusing on the beginning of the musical score, where they were processing the musical information - meters, clefs, initial notes with the proper sol-fa names, regardless of the type of the notation. The second half of a period-like musical structure was observed by the students to a lesser extent, because the first four bars make the reading comprehension easier.

All students performed the examples with relative sol-fa, except the task with C-key and the folk song. So they used one of the main principles of the Kodály concept. It was revealed that students used music reading strategies, because they memorized the melody. Thermographic pictures show that students tended to read the melody instead of the rhythm.

Gaze opacity maps and thermographic pictures of the musical scores revealed that skilled music readers tend to predict the rhythm of the melody on the basis of the position of the musical notes.

5.2. Study 2. Rhythm reading skills of mainstream school students

We conducted our research in a public school (N=18) to examine their rhythmic reading skill on a Kodály reading exercise in March, 2014. Our questions were:

1. What is the level of music reading skills of fourth graders in mainstream education?
2. How can period like music structure enhance and facilitate music reading?
3. Where do students fixate on the musical score?
4. Are there gender differences in the music reading process?

5.2.1. Methods

5.2.1.1. Participants

In the present study, 18 fourth grader primary school students’ (9 boys and 9 girls) rhythmic reading processes were examined. Students have one music lesson (45 minutes) a week and none of them attend a music school or learn a musical instrument.

5.2.1.2. Material

The musical task for students was an eight-bar, periodic-like, sol pentatonic exercise from Zoltán Kodály's *333 Reading Exercises,* in ¾ time signature with simple rhythms (Figure 16). The exercise contains the same rhythmic pattern five times. The music example was notated by a MuseScore 1.2. music notation software.

Fig. 16 Kodály's reading exercise

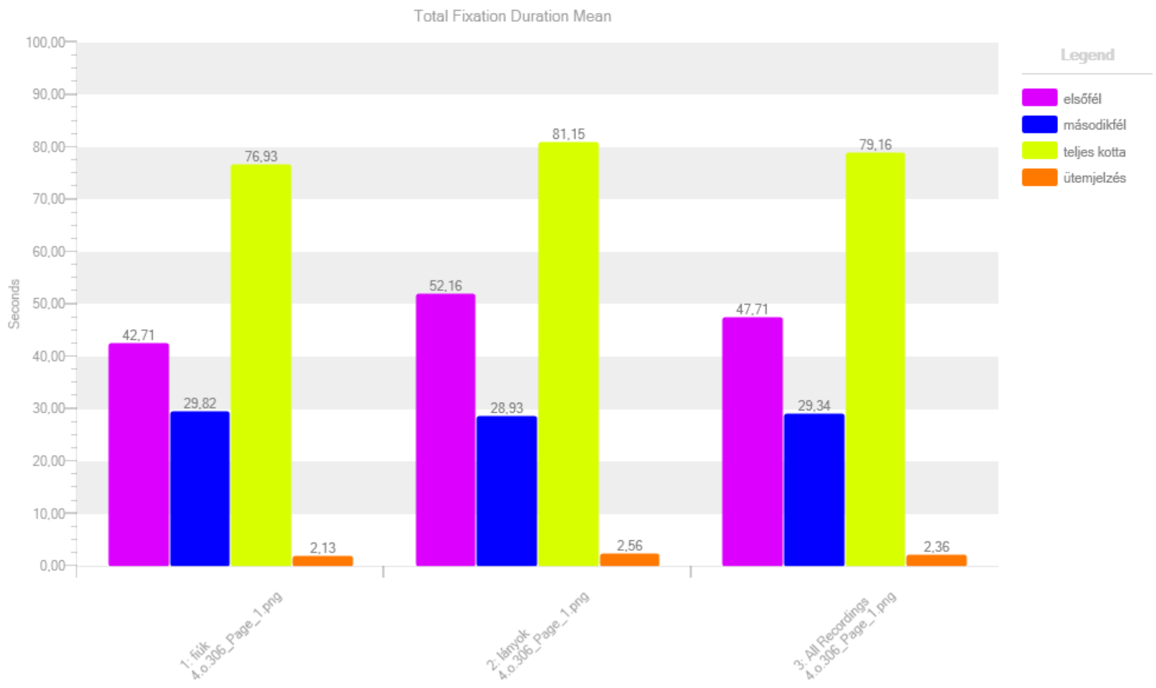
5.2.1.3. Procedure

Eye movements were recorded by a Tobii 1750 Eye Tracker Tobii T120 with Tobii Studio 2.2.7. software in the public school. After 30 seconds silent reading students were asked to sound the exercise by clapping or with rhythm names. There was no time limit for loud reading each task. A session for each child lasted approximately 6-10 minutes.

5.2.2. Results

We divided Kodály's composition into areas of special interest (AOIs), two four-bar half-periods and examined the number of fixation on three different areas, namely on the total music score, and on the two half periods. On the second half of the period, fixation counts are less, than on the first half, that means, the musical text became more familiar to the students, they can understand its musical meaning towards the end (boys 149s, girls 239s). The number of fixations on the first half of the musical sheet was lower for the boys (250s), than the girls (432s) (Figure 17). Time signature was observed about 2 ms. Two students did not looked at the time signature, however this is one of the most important component of a musical score.

Fig. 17 Total Fixation Duration Mean of the special areas of interest of Kodály’s composition

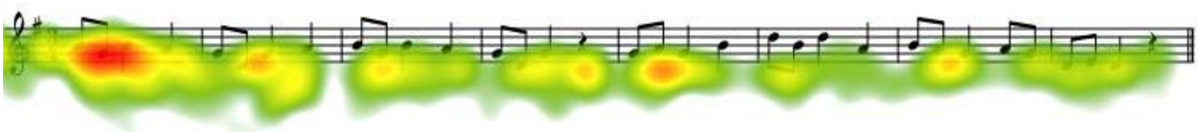


Video records revealed that neither boys nor girls were unable to keep the metrum, as for students read music with rhythm names, we explored that they are unable to name or clap even the simple rhythms. However, 64.70% of students claimed that the exercise was easy for them. 76.47% of students’ last grade average was 5 and 29.4% of them was 4 and neither of them got 3 from music. The mean average of music grade of all students is 4.72, which implies that they have excellent musical skills. It can be assumed that the teachers’ assessment methods in primary schools with a general curriculum do not cover the different fields related to musical knowledge.

In the research we explored characteristics of music readers, however it was a small sample we found significant differences on the bases of heat maps. While girls were reading music more scattered and were focusing more on individual notes (Figure 18), boys tended to read music more fluently and focused (Figure 19).

Fig. 18 Heat map of the girls' music reading

Fig. 19 Heat map of the boys' music reading



In the research, 21 music teachers were asked if they would like to use more music reading materials. 66% of the teachers said teaching is inefficient if they can use only one single musical textbook.

5.2.3. Summary

In the research we focused on mainstream school students' rhythmic reading skills. The eye tracking research revealed that the pupils' rhythm reading skills lag behind the requirements of the National Core Curriculum. On the basis of the video recordings, students were unable to keep the proper tempo or name the rhythm syllables.

Thermographic pictures show that the same rhythmic patterns get fewer and fewer fixations towards the end of the musical period. The time signature was not observed at all. Students fixated on the middle of each bar of the music reading exercise. Although it was a small sample, we found differences between girls and boys' music reading process. Boys tended to read music more fluently and focused.

5.3. Study 3 Testing 10-14 year-old music school students' music reading skills

Our studies were conducted in music schools in European countries, Hungary, Luxembourg and Germany in January 2015. The purpose of the present research was to examine 10-14 music students' rhythmic and melodic reading process studying with different music teaching methods. Our questions were the followings:

1. What is the music reading skill level of 10-14 year-old students?
2. How can period –like music structure enhance and facilitate music reading?
3. Where do fixations occur on a musical score?
4. Are different music teaching methods a factor in the music reading test?
5. Is gender a factor in performance for different parts of the music reading test?

5.3.1. Methods

5.3.1.1. Participants

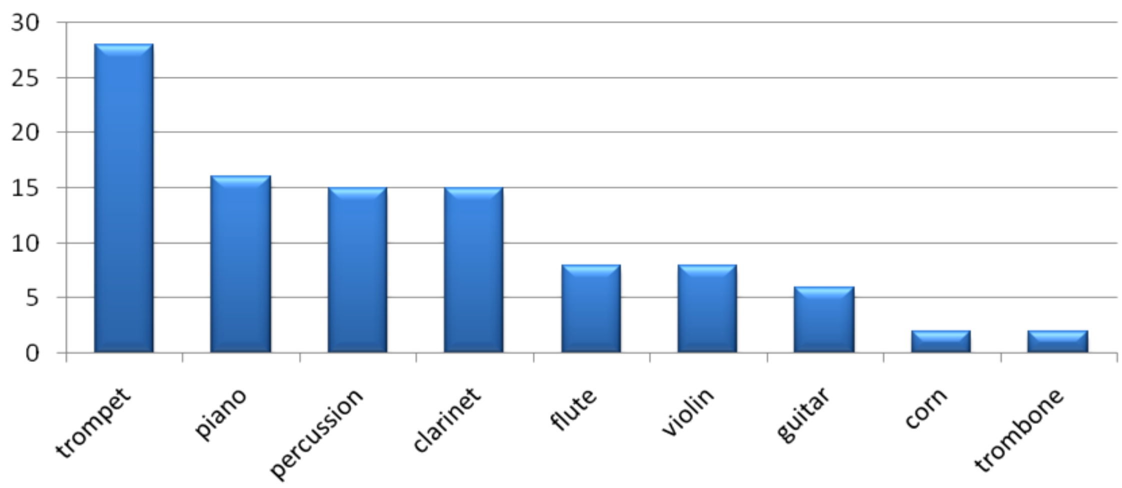
The participants (N=53) were music school students between the ages of 10-14. The participants' numbers of the three different countries are shown in Table 7. The participating students study different musical instruments, 55% of the students' study wind instruments, most of them (32%) play brass instruments, and pianists are 16% of the sample.

Table 7 Participants of Study 3

	Luxembourg N=19		*Germany N=16*		*Hungary N=18*		*Total*
	boys	girls	boys	girls	boys	girls	
10 years	9	5	3	5	6	5	33
14 years	3	2	2	6	5	2	20

Only 14% of the students play different string instruments (Figure 20). All students have two 45-minute-loon solfege lessons in a week, but they study with different methodology and in traditions. Hungarian students usually read music with relative solmization, while in Luxembourg students study music with absolute sol-fa names, following the Dalcrose method.

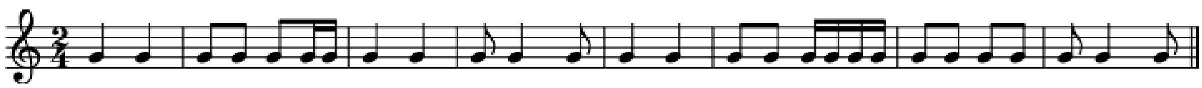
Fig. 20 The instruments of the music students (%)



5.3.1.2. Material

The first three music score contain rhythm tasks with different meters. One rhythm and all melody tasks for students were eight-bar exercises and resemble the style of a musical period. Albert Siklós (1923) considers those eight-bar units as periods in which their content varyies in the second phase of the period. Eight-bar and period-like songs are common in every music book that usually contains four two-bar-motifs and two four-bar half-periods. Timing is essential in music and most of the musical information is coded in the meter and the rhythm. I composed the stimulus rhythmic exercises for the experiment considering the requirements of music school curricula in Hungary and abroad (Figure 21).

Fig. 21 Simple rhythm reading exercise for music school students



The second rhythm exercise is more complex and longer (16 bars), and includes several rhythm patterns (Figure 22).

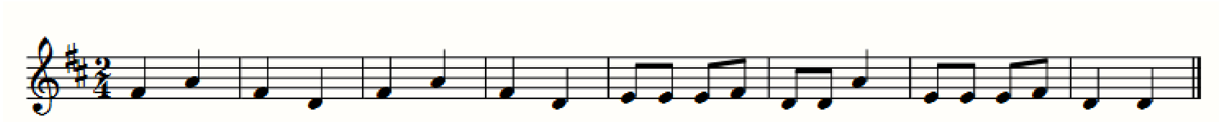
Fig. 22 More complex rhythm reading exercise for music school students

The third, the most complex rhythm task includes ties, repetition, and various dotted rhythm values (Figure 23).

Fig. 23 Complex rhythm reading exercise for music school students

The melodies were from Zoltán Kodály 333 singing exercises, all with different time signatures. The eight-bar melodies were composed in different pentatonic scales (do, sol and la pentatons). The melodies were previously unknown to the participants, providing an authentic sight-reading task in each measurement. The melodies only contained quarter and semiquarter notes, they contain smaller intervals and they are primarily stepwise, to ease the recognition of the notes (Figure 24).

Fig. 24 Zoltán Kodály's reading exercise



5.3.1.3. Procedure

Eye movements during playing were recorded by a Tobii 1750 Eye Tracker Tobii T120 with Tobii Studio 2.2.7. software. In the research the students got 3-3 increasingly complex tasks, three rhythm exercises and three melodies from Zoltán Kodály. After half minute silent studying the music score on the computer screen, students should perform them.

5.3.2. Results

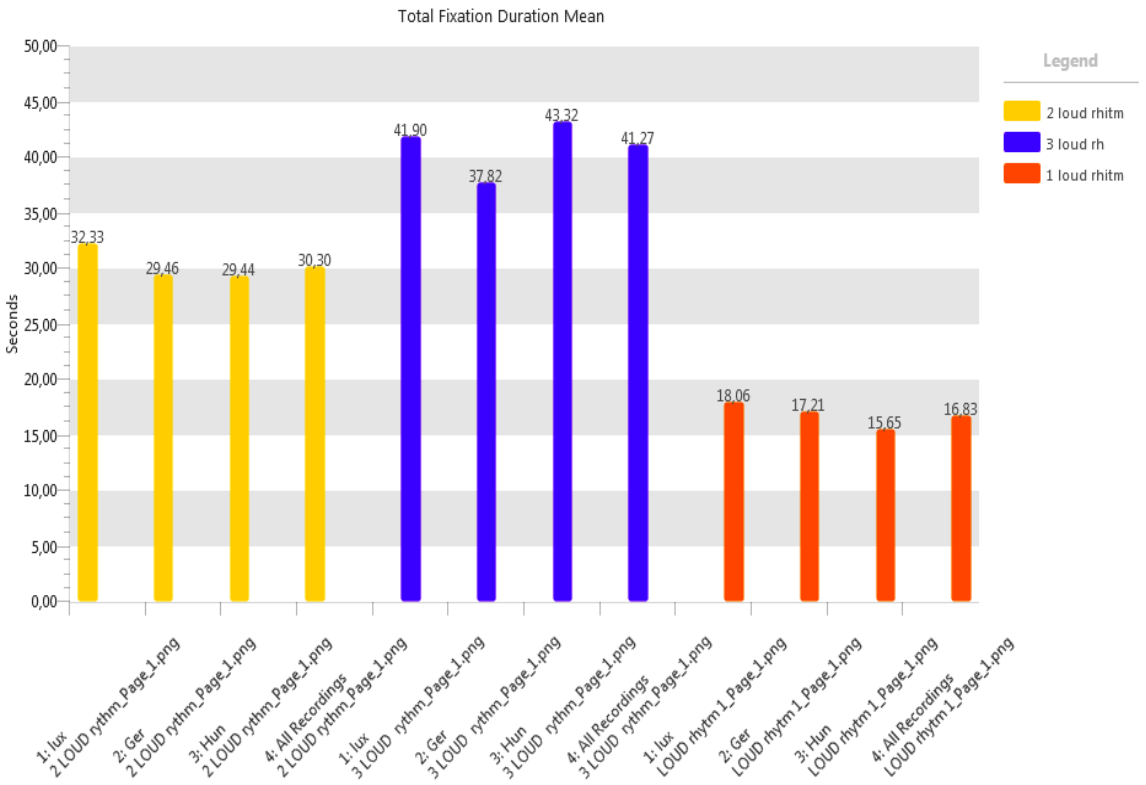
Information processing occurs during fixations. According to a hypothesis fixation duration measures cognitive processing time. There may be several factors that contribute time to each fixation. In general, fixation durations are considered to reflect the time and effort needed to process the fixated information. If we compare the results of students from different countries we can conclude that the means of total fixation duration are approximately similar in the case of silent and loud music reading, as well (Table 8).

Table 8 The means and sums of the total fixation duration on Kodály's reading exercise

		Kodály's melody silent reading		*Kodály's melody loud reading*	
	N	Total fixation duration mean	Total fixation duration sum (s)	Total fixation duration mean	Total fixation duration sum (s)
Luxembourg	19	26.26	210.10	18.60	148.76
Germany	16	25.47	203.77	16.87	134.97
Hungary	18	24.47	269.13	17.41	191.54

Similar tendencies are shown in Figure 25 in connection with the loud rhythm reading examples. The use of eye fixation data helps us to examine skill development in music-reading tasks. The means of total fixation duration are similar in the three samples and increase with the complexity of the different tasks.

Fig. 25 The means of the total fixation duration of the loud rhythm reading exercise



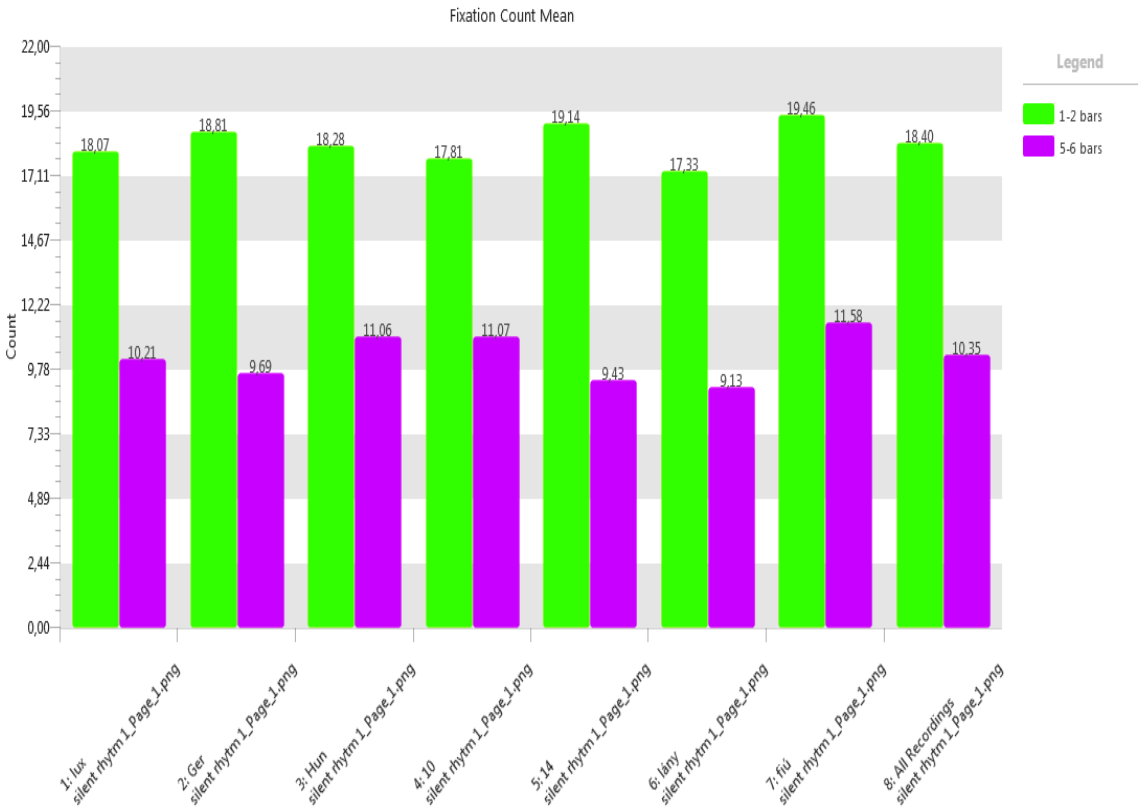
5.3.2.1. Effects of musical structure

Eye movement recordings can also provide a valuable tool for gathering data about structural processing in music. From the point of view of reading research, a question arises how predictable are musical structures could be. According to Sloboda (1976) music and language share the common tendency to evoke strong expectations, or sophisticated guessing, phrase units of a period could be determinants of visual processing in music reading. The results suggest that the knowledge of musical patterns and text characteristics strongly influence fixation durations. We divided the rhythmic tasks and Kodály's composition into specific research areas (AOIs), namely into two four-bar half periods and also four two-bar musical motifs.

In the first rhythmic exercise we found that the fixation counts means of all participants on the first two bars was almost twice longer (18.40 ms), than on the second four bars (10.15 ms), which have a similar and familiar form, metrical structure and melody.

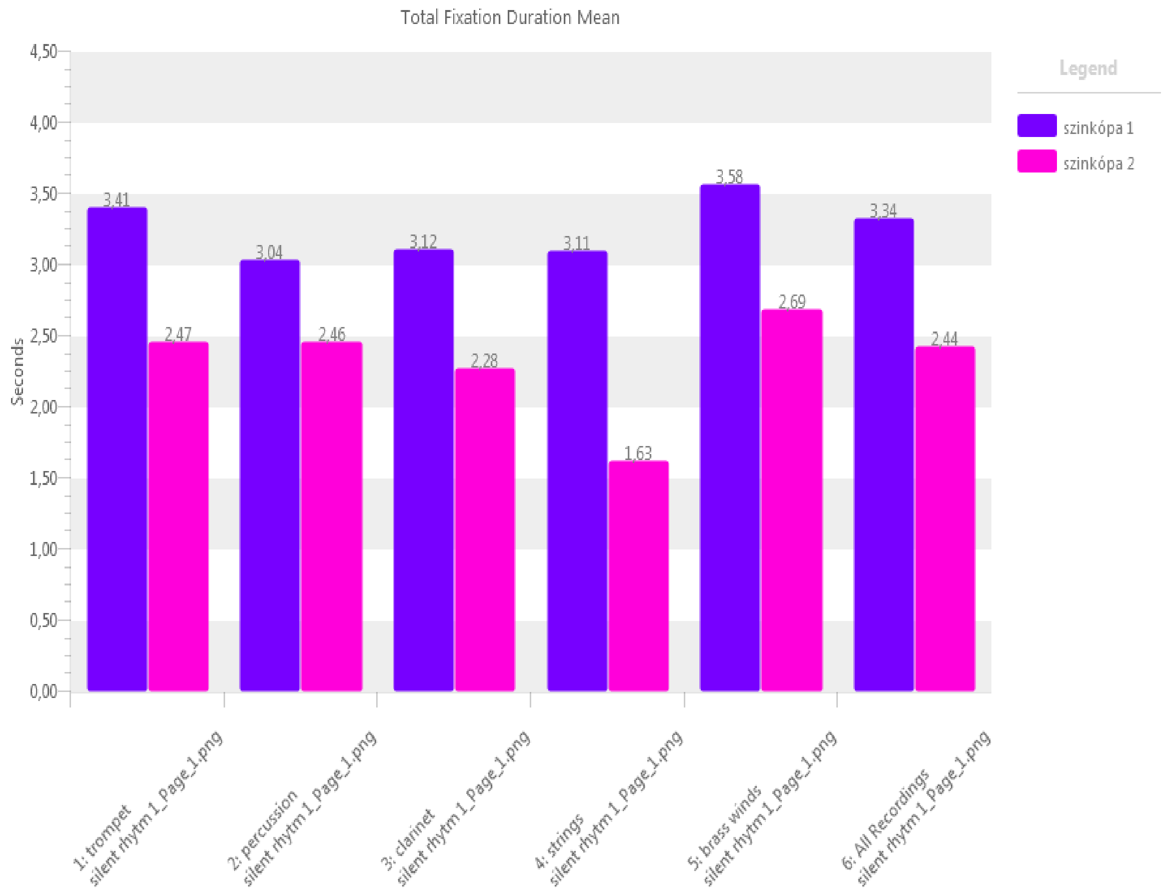
All selected groups show similar results in the three countries. The collected data reveals the significance of the knowledge and understanding of musical structures, and also the knowledge of musical styles. Melodies with good musical forms or structures enhance and facilitate music reading (Figure 26).

Fig. 26 The means of the total fixation duration on the two selected areas of the musical period



When the same rhythmic pattern, here syncope, appears in the musical example again, the second time its mean of total fixation duration is approximately the half amount (10.72s first, 5.70s the second time). Musical structures are important in reading materials aiming to enhance and facilitate students reading skills. With the help of eye tracking analysis we can compare the results of the different instrument groups (Figure 27).

Fig. 27 The means of the total fixation duration of the different music instrumentalists



5.3 2.2. Heat maps

The importance of this research is that we can compare the effects of different music reading methods. In our research we found similar results in the quantitative and qualitative ways in the three countries however they study music with different methods (books, system etc.). This phenomenon is the same in reading where universal factors exist (Figure 28, 29 and 30).

Fig.28 The heat map of the silent rhythm reading of all Hungarian students

Fig. 29 The heat map of the silent rhythm reading of all Luxembourger students

Fig. 30 The heat map of the silent rhythm reading of all German students

We can compare the heat maps of the silent and loud reading of the students. Loud rhythm reading needs more effort as students should sound it (Figures 31 and 32).

Fig. 31 The heat map of all students' silent readings

Fig. 32 The heat map of all students loud readings

We can see clearly on the base of the heat map how students became more confident and fluent during music reading process in the different ages (Figures 33 and 34).

Fig. 33 The heat map of the loud music reading of 10-year-old students

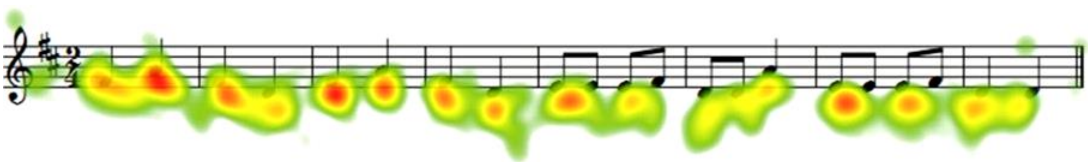


Fig. 34 The heat map of the loud music reading of 14-year-old students

Individual differences can be revealed with the help of the heat maps. Ten-year old student's music reading is characterized by note-by-note process (Figure 35).

Fig. 35 The heat map of the loud music reading of one 10-year-old student

5.3.3. Summary

Eye tracking analysis proved to be an appropriate tool for assessing 10-14 year-old students' rhythm and melody reading skills. As expected, students with better reading skills spent less time on the target exercises compared to other students. Familiarity with music structures facilitated processing of the music reading material.

The characteristics of Kodály's composition, e.g. the period-like structure and pentatonic scale, enhance students reading skills. Differences were found between the achievements of different instrumentalists. Violin players need less time to read the exercise than brass wind players. However, all types of instrument players show similar tendencies in connection with pattern reading.

We found similar results in the quantitative and qualitative ways children from three different countries study music with different methods. We also found different development stages. Pattern recognition of a musical period's elements and patterns facilitate music reading. With the analysis of music reading notation we leanr more about the reading process in general, as during the silent and loud reading visual symbols based on conventions are decoded.

Loud and silent reading was also examined heat maps of all students reveal more concentration and fixations during loud music reading. The chunking process can be observed by the heatmaps of 14-year-old students' music reading, while ten years old students tend to read music note by note.

6. Online assessments of testing students' music reading skills

The online empirical researches were based on the background discussed above and also on the results of our previous eye tracking studies. The cross-sectional pilot studies were conducted online, and were followed by large-scale measurements in specialized music and mainstream schools in Hungary.

6.1. Assessment tools used in the online music reading test

The development of our online test could be considered as an important step in music education. In Hungary, there is not a unified evaluation system for regular assessment of solfege or general music skills in contrast for example in Luxembourg. By the age of ten, students are assumed to have acquired the relevant knowledge and skills related to the appropriate level of music literacy as defined by the Hungarian National Core Curriculum. All tasks of our online tests are based on this central music curriculum. We aligned our music reading test to the following systems and approaches:

1) the system of Western music notation

2) the general requirements of music and solfege curricula in mainstream and specialized music schools in Hungary

3) the Kodály concept (Gönczy, 2002)

4) Erősné's Model of Basic Musical Skills (1992)

5) the digital materials used in solfege education (EarMasterPro series) (Buzás, 2014).

The task structure of out two online test versions reflects the components of music education in a varied way. The different areas of music reading skills were covered by the following subtests: rhythm reading (including simple meters, the symmetrically compound meters, and some rhythm values and patterns), melody reading (including different musical notation systems, recognition of melodic patterns, such as intervals, scales, triads or musical signs). Melody and rhythm reading with soundtracks were also integrated. Tasks with timbre and dynamic reading (signs and concepts), music reading from different notation systems, such as letter notations or hand signs were explored. For music school students our test contained 55 closed items. For mainstream school students a similar assessment form containing 35 items was developed. All of these 35 items are parts of the music reading test for music school students. Our online test also contained an appendix of three map reading tasks, as indicators of students' spatial abilities

(Appendix B, Figure 124-126). I assumed that visual/ spatial orientation is related to music reading skills.

In developing the tasks we relied on the possibilities offered by computers, such as variety of form, visualisation and sounding opportunities. For examining students' music reading skills we notated our musical examples with MuseScore 2.0 free music composition and notation software.

Table 9 summarizes the structure of the tests. A brief description of the subtests follows. Examples given here show the eDia format the participants saw on their computer screen. (These English examples are the translations of the Hungarian originals for demonstrative purposes.)

Table 9 The system of the music reading online test versions

The aspects of the grouping tasks	*Contents of tasks' groups*	*Mainstream school's tasks*		*Music school's tasks*	
		Nr.	Numbers	Nr.	Numbers
Rhythm reading	Metrum				
	2/4	1	2	2	2,5
	4/4	1	1	1	1
	3/4	1	3	1	3
	6/8			1	4
	Rhythmic elements				
	Bars	4	5,6,7,8	4	6,7,8,9
	2/4	1	9	1	10
	3/4	1	10	2	11, 12
	4/4	1	12	2	13, 14
	Identifying a song's rhythm	1	13	2	16
Melody reading	Clefs	1	14	3	18, 19, 20
	Tones	1	15,16	4	21, 22, 23, 24
	Intervals	2	17	3	27, 28, 29
	Scales	1	21	2	32,33
	Harmonies	1	22	3	30, 31,51
	Tonality	1	24	3	36, 25,26
	Identifying a song's musical notation	2	23, 29	2	45, 46
Reading from different musical notation systems	Hand signs	2	32	1	54
	Staff notation		31	1	53
Improvisation	Matching of period-like music patters	1	30	1	49
Style recognition	Style and characteristics	1	34	1	43
Music reading with supporting soundtrack	Rhythm exercise	1	27	1	56
	Melody exercise	1	28	1	42
Aural skills/ Audiation	Intervals			3	39, 47, 48
	Scale			1	41
	Harmony			1	40
Timbre	Instruments	1	20	2	37, 38
	Musical groups	2	25, 26		52
Musical concepts & signs	Musical form			1	44
	Tempo	1	33	1	50
	Instruments	2	18,19	2	34, 35
Dynamic reading	Musical signs		35		55
Spatial skills	Map reading exercises	3	36, 37, 38	3	57, 58, 59

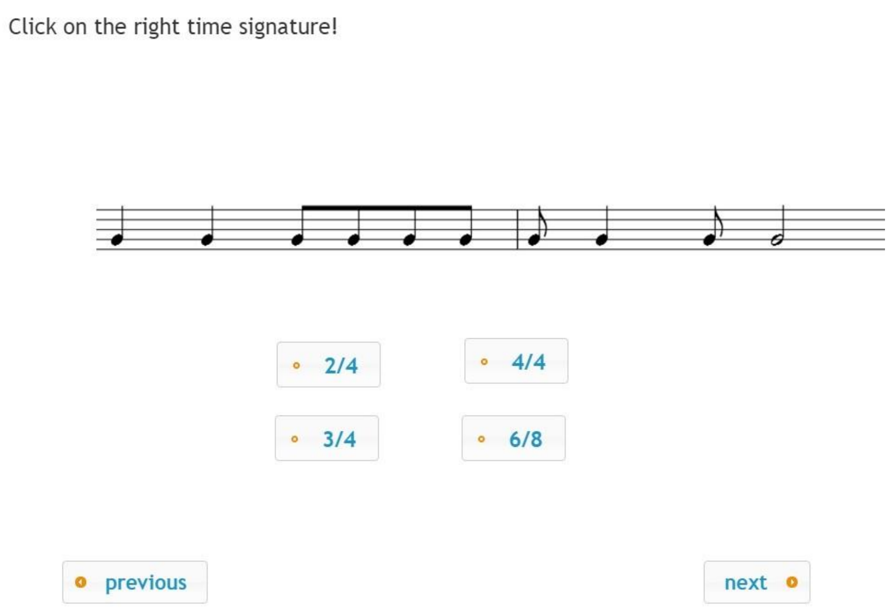
6.1.1. Rhythm reading tasks

Rhythm reading is based on the abilities of visual perception and audiation of students to recognize and memorize temporal patterns. According to Elliott (1982) rhythm-reading ability is the single best predictor of instrumentalist students' general music reading performance. For testing students' performance we developed thirteen rhythm reading items, based on meter, rhythmic pattern discrimination, and auditory-visual discrimination.

6.1.2. Simple and compound meters

In the first four meter discrimination tasks, students had to decide which of the given time signatures fits to the rhythm sample. Students had to choose between 2/4, 4/4, 3/4 and 6/8 meters (Figure 36).

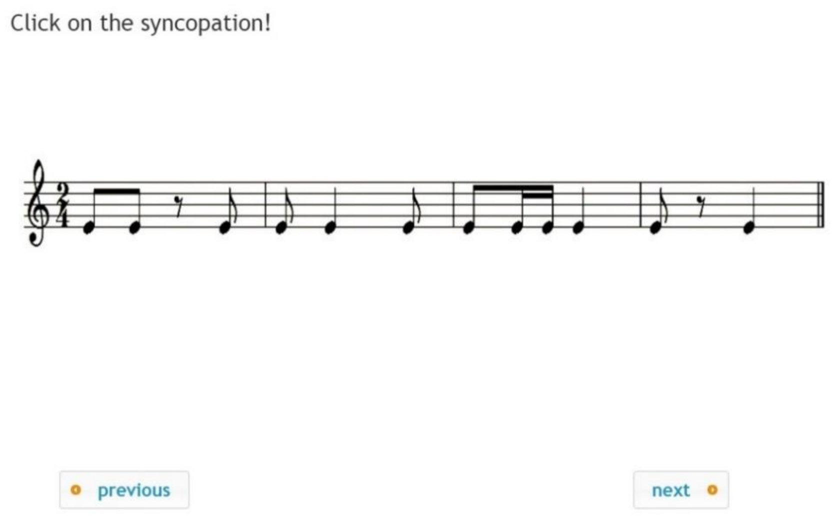
Fig. 36 Example of a metrum exercise



6.1.3. Rhythmic patterns

Students were asked to discriminate a few rhythmic patterns, such as syncopation, Lombardic rhythm or different types of musical rests that are contained in a four or eight bar period (Figure 37).

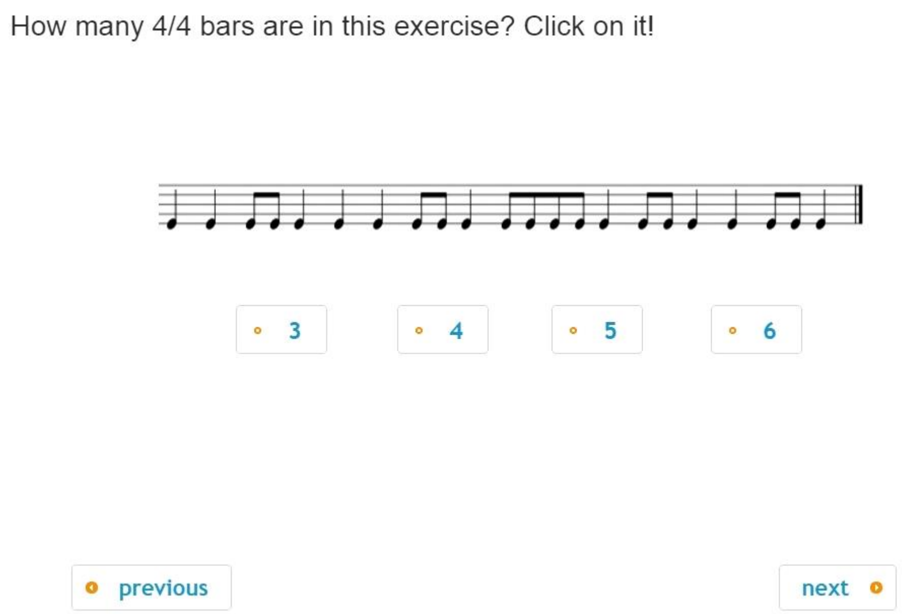
Fig. 37 Example of rhythmic pattern identification



6.1.4. Recognition of bars in a musical example

Students must decide the correct number of bars that are contained in a musical sample started with different time signatures (Figure 38).

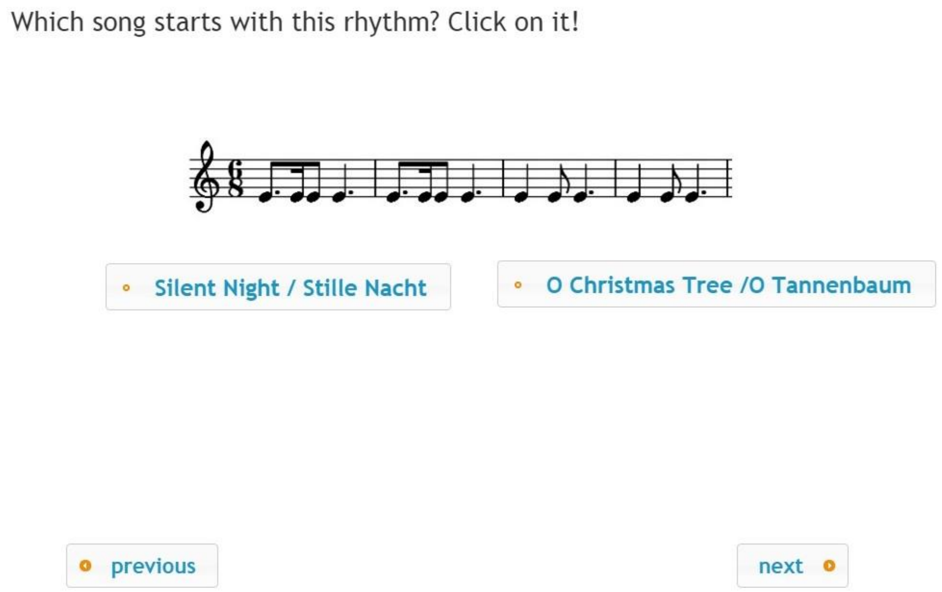
Fig. 38 Example of metric identification



6.1.5. Identify a song for its rhythm

The knowledge of different rhythmic patterns enables students to recognize songs from their rhythms. In our tasks the songs are well-known in all European cultures; *Silent night, holy night* and *Oh, Christmas tree*. Students learn and sing these songs from kindergarten ages or even earlier. Students had to decide which song fits to the rhythm notation shown to them (Figure 39).

Fig. 39 Example of a rhythm reading exercise

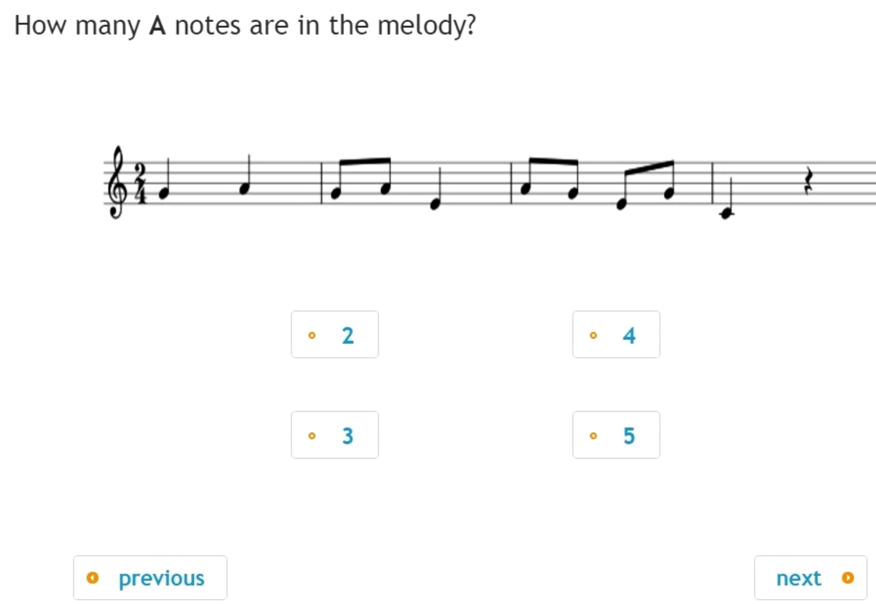


6.1.6. Melody reading

6.1.6.1. Identifying clefs and note names

The knowledge of basic clefs are the starting point for later developing transposing skills. Keys are useful in many ways; students can choose a register that is comfortable for their voice or instruments. After having practiced the G-clef we proceed to the F and C-clefs in specialized music education. For communication about music and as an aid to memory (mnemonic) is necesarry to assign names to pitches. We asked students in varied ways to identify the given music notes by clicking on them or counting them (Figure 40).

Fig 40 Example of a melody reading exercise



6.1.6.2. Identifying intervals and harmonies

Intervals are grouped into two sections. One comprises perfect intervals: perfect fifth, fourth, octave and unison. The other includes intervals that occur in two types, in small and big steps. Similar to the two types of seconds, there are two sizes of thirds, sexts and septims – major and minor types. In primary school, students learn the perfect intervals from the fifth grade. However, they already learn songs containing these from the first grades, unaware of the concept. The significance of intervals are supported by eye-tracking studies. Students look at the space between the musical notes more often, than exactly on the note, and the knowledge of intervals enhances intonation and singing skills, as well. Students had to identify the asked perfect intervals (Figure 41).

If more intervals are stacked vertically in tonal music, they form chords. We asked students to identify the basic kinds of chords, such as major, minor, diminished or augmented. As the basis of polyphonic hearing and interpretation, the perception of harmonies requires multimodal musical thinking (Figure 42).

Fig. 41 Example of an interval exercise

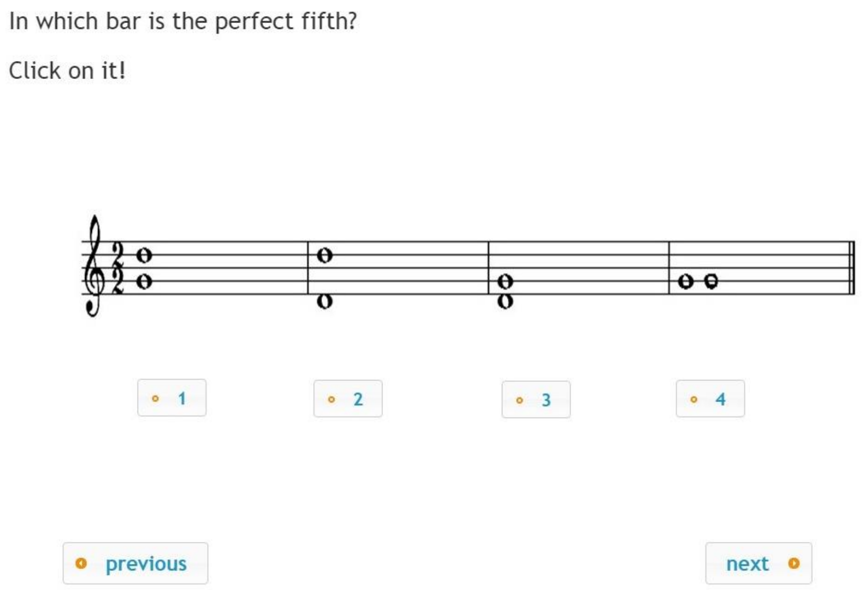
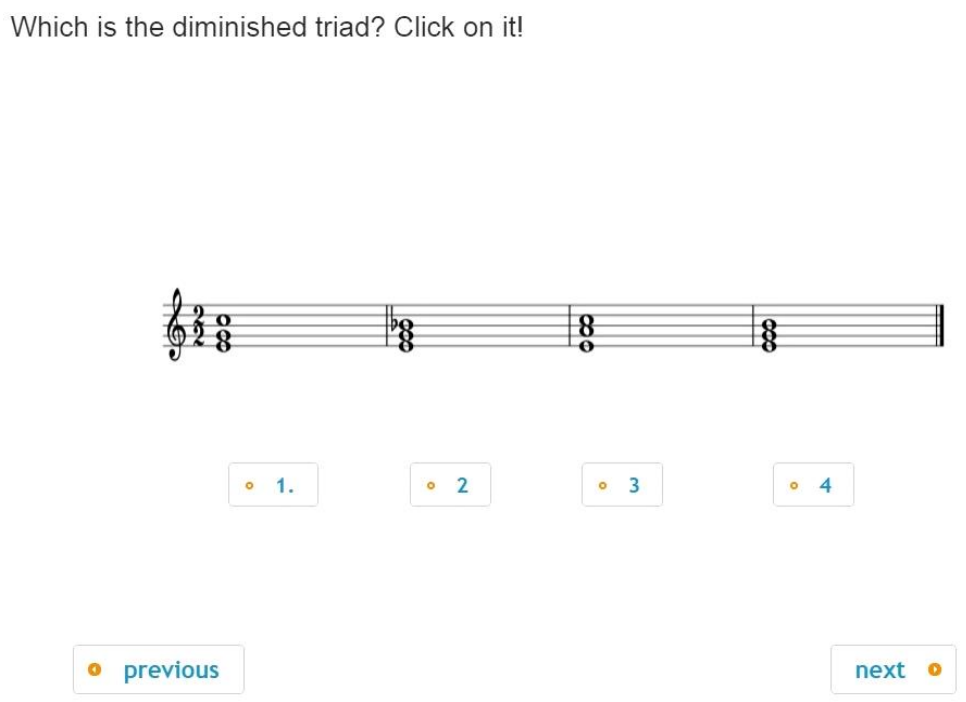


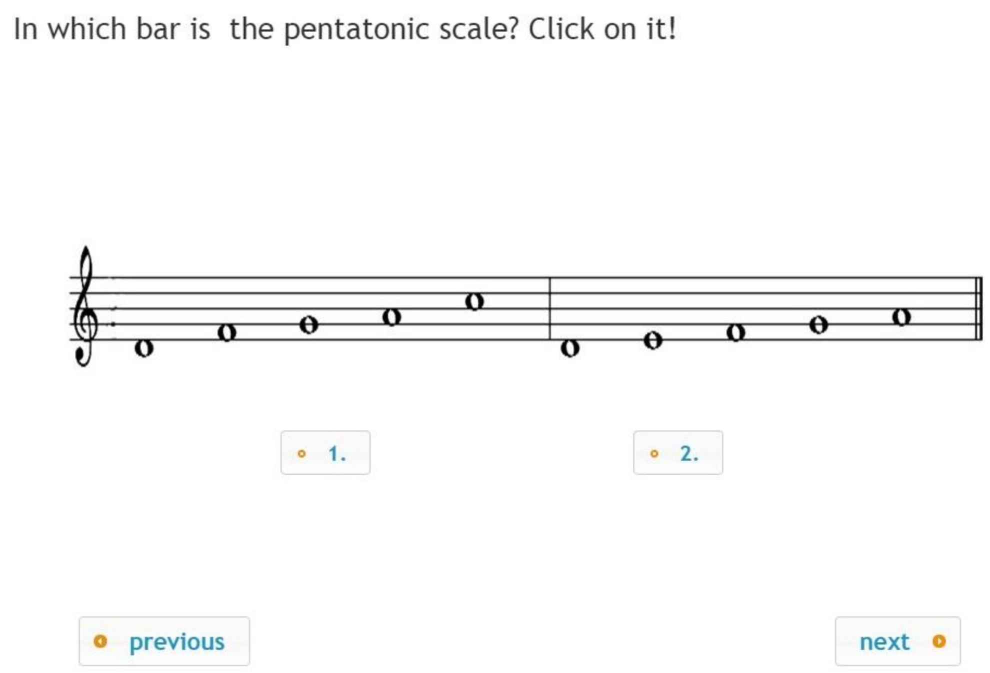
Fig. 42 Example of a chord exercise



6.1.6.3. Musical scales and tonality

Musical scales and modes can be defined as a set of pitches in a musical system, usually form the tonality of a musical composition. The number of tones in the octave can be devided in several ways. Pentatonic scales can be built on each note of the scale. The Hungarian folk music tradition is based on the pentatonic system, usually with a fifth change. This means that the second melody line is above or under to the first line of the folk song with a perfect fifth interval. Diatonic scales comprise the arrangement of half steps and whole steps (major and minor seconds). Students have grown up hearing the music of Western culture, thus the most natural scales for them are the major and the natural minor scales. Tonality refers to hierarchical connections between the pitches of a composition. Students were asked to define the given melody's tonality. They were offered a choice between G-major, g-minor, D-major and d-minor. Identification of the last note and key signatures could help them (Figure 43).

Fig. 43 Example of a scale exercise



6.1.6.4. Recognition of songs and their style

The task consists of a well-known melody, and students can choose the song which fits the musical notation from popular children's songs, such as *Kis kece lányom, (My nice little daughter…), Szegény legény vagyok én (I am a poor boy…)* and *Megfogtam egy szúnyogot… (I caught a mosquito…)*. In Hungary, students learn not only children songs, but several folk songs and their characteristics to distinguish between old and new-type folk songs. There is usually a descending fifth change in a pentatonic melodic structure in old-type folk songs. One of the most well-known examples of an old-style folk song is *Megrakják a tüzet… (They feed the fire…),* where the descending perfect fifth change can be observed in the third and fourth lines (Figure 44).

Fig. 44 The music score of an old-style Hungarian folk song

New-style folk songs are characterized by the domed melodic line, with a rising fifth change, with A A5A5A or A A5A5v A or ABBvA melodic structures. The domed melodic line can be observed in the following example (Figure 45).

Fig. 45 The music score of an old-style Hungarian folk song

In the exercise students are asked to identify the style of a folk song based on its characteristics.

6.1.7. Dynamics and tempo reading

Usually Italian words indicate the changes in volume. *Crescendo* means growing and *decrescendo*, means gradually becoming softer. Our example was composed by Béla Bartók and contains different musical signs. Bartók's first volume *For Children* (1909) contains 42 short piano composition based on a Hungarian folk tune. Students had to identify the sign on the musical excerpt (Figure 46).

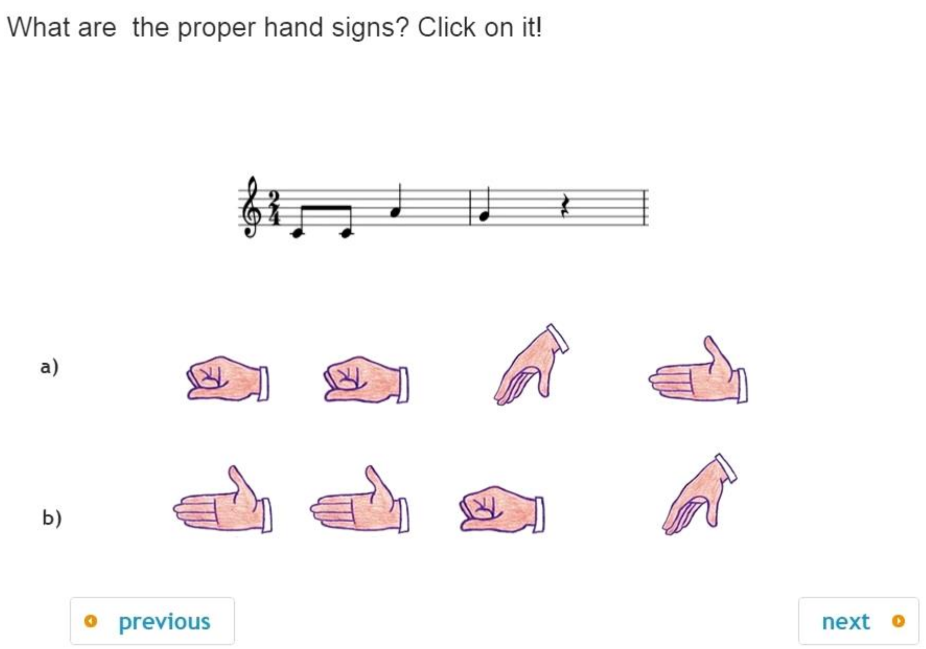
Fig. 46 Example of a dynamic reading exercise

In case of tempo, they were asked to define the meaning of *Allegro*, which is one of the most common tempo signs.

6.1.8. Reading from different notation systems

Different music reading signs and symbols are taught from the first school years and, in the case of hand signs, even earlier, in the kindergarten. Letter and stick notation are also required in the curriculum. Our example for reading hand sings was the first line of a well-known Hungarian children song, *A part alatt… (Along the riverside…)* (Figure 47).

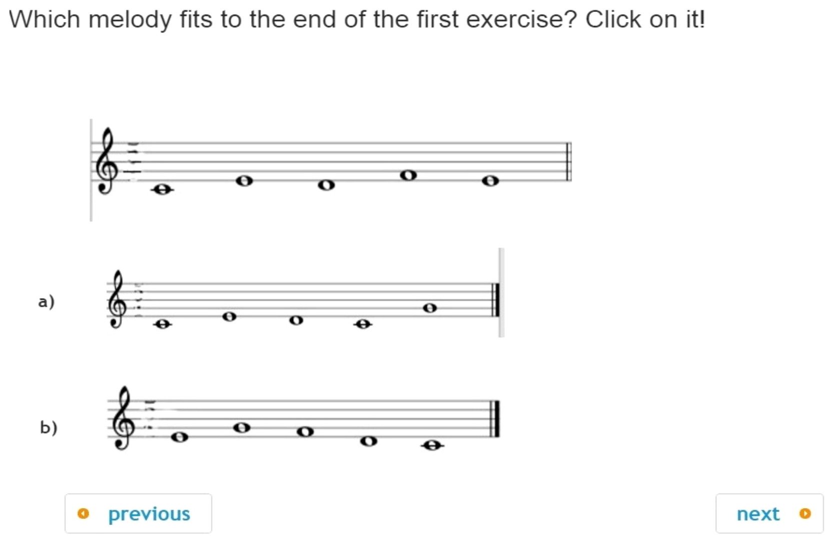
Fig. 47 Example of an exercise with sol-fa notation



6.1.9. Improvisation and composing skills

The knowledge of certain musical patterns, structures and of course a wide range of children songs may enable students to use their improvising skills. Predicting music patterns contributes to the improvement of music reading performance in elementary students. In the task, students had to determine the proper musical ending (Figure 48).

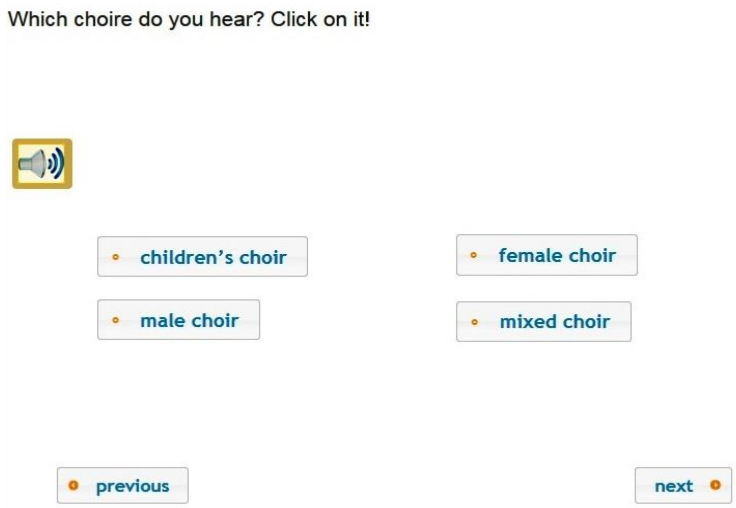
Fig. 48 Exercise related to students' improvisation skills



6.1.10. Timbre discrimination and reading

The easiest way to examine students tone or timbre hearing is testing their knowledge about musical instruments or music groups. The stimuli played were music samples from well-known musical compositions, and students had to determine the types of instruments or musical groups. Figure shows an example for timbre discrimination. The stimulus is an expert from Thomas Tallis composition entitled: *If you love me* performed by the Cambridge Singers (Figure 49).

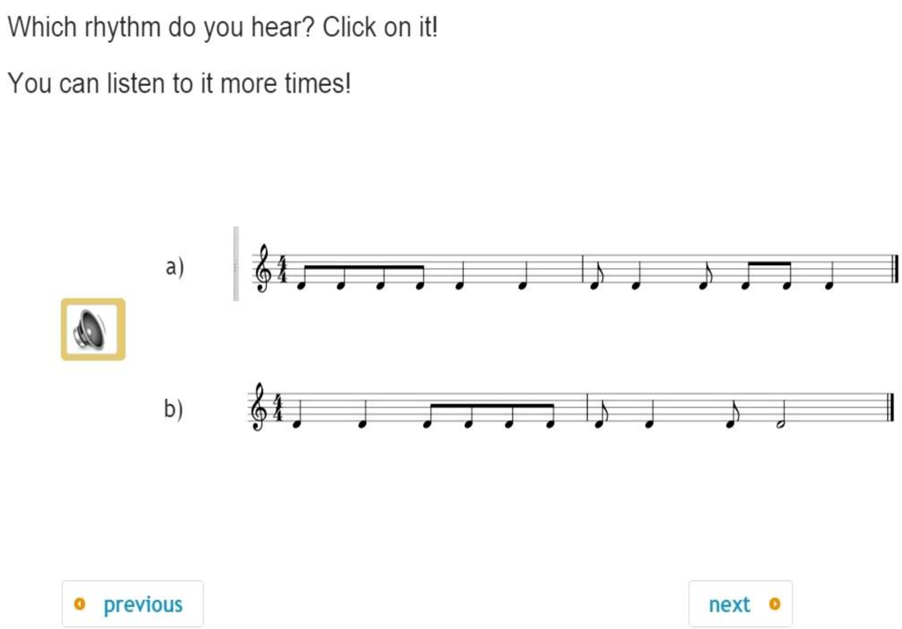
Fig. 49 Exercise related to students' timbre hearing



6.1.11. Visual connection

The ability to perceive the connection between the visual and the auditory modality determines the development of music reading and writing. In our tasks participants had to choose one of two musical examples that fit the melody or rhythmic soundtrack being heard (Figure 50).

Fig. 50 Example of an exercise with soundtrack



6.1.12. Aural skills / Audiation

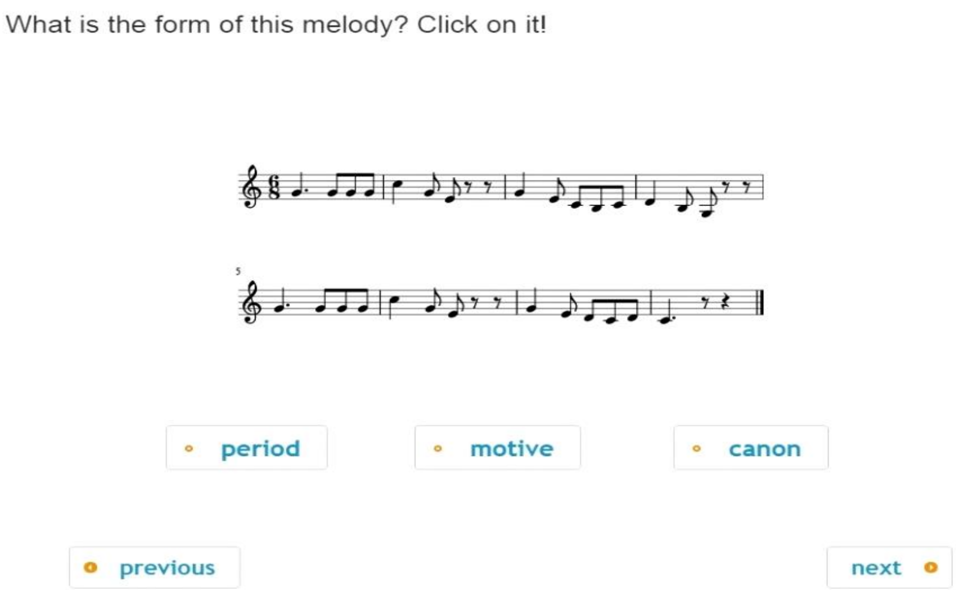
With a piano soundtrack, we tested whether students could recognize intervals, scales or triads with and without the musical notation. In the example students were asked to choose between perfect intervals (Figure 51). We investigated the influence of auditory perception on music reading performance.

Fig. 51 Example of an exercise with perfect intervals

6.1.13. Musical concepts

Period is one of the most important musical units of meaning in Western music. Students should determine the form of a Mozart piano sonata fragment based on its structure. The knowledge of musical instruments is also a part of the curriculum. Students had to identify string and brass instruments (Figure 52).

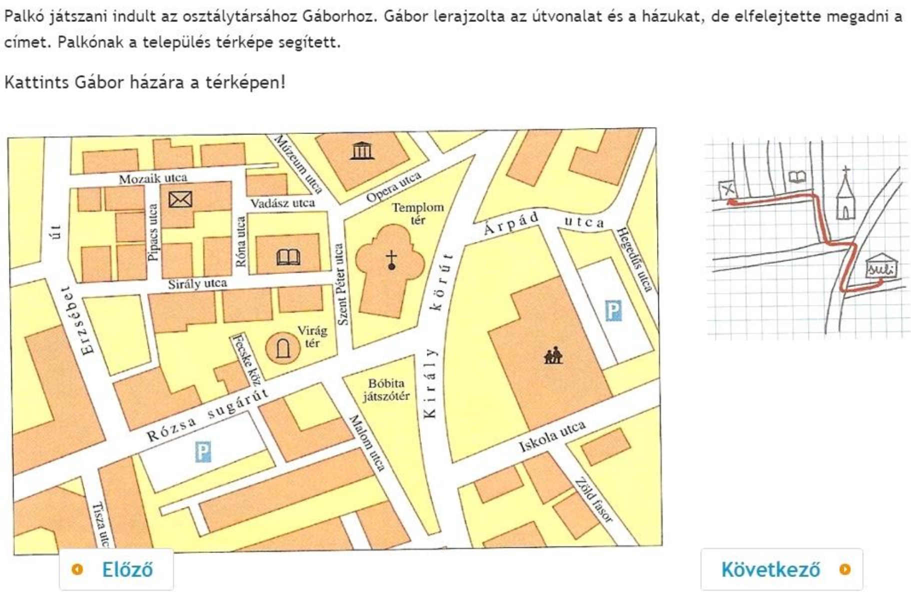
Fig. 52 Example of a musical concept task



6.1.14. Spatial skills: map reading

Spatial skills, the awareness of directions, visual orientation may be related to music reading. The three map reading items were developed by Ágnes Maródi, a PhD student at University of Szeged, Doctoral School of Education. The tasks were developed especially for this study (Maródi et al., 2015) (Figure 53).

Fig. 53 Example of a map reading task



6.2. The background questionnaire

To gather contextual information, students were asked to respond to the background questionnaire that took 15 to 20 minutes to complete after the online music reading tests. The questionnaires contained 36 questions for students to investigate the relationship between music reading skills and several background variables. We were asking students about the music reading test itself, their school results, social backgrounds, attitudes towards different music lessons, singing and reading, concert experiences and future musical plans. We also investigated metacognitive strategies and included questions relating to technology, especially the internet. In our survey we gathered information about students' access to a computer at home, attitudes towards using a computer, and the frequency of computer usage. The structure of the background questionnaire is displayed in Table 10.

Table 10 The system of the background questionnaire in connection with music reading

Background questions	Research area	Number of the research questions
gender, age, class, parents' highest level of education, type of settlement, foreign language, type of school, books' number	socio-economic background	2, 3, 4, 5, 6, 11, 28, 33, 34, 35
Do you study solfege?	music reading	7
What is your instrument?	music reading	10
How many years do / did you study solfege?	music reading	8
How many years do you study in music school?	music reading	9
How much do you like the different parts of solfege?	attitude towards music reading	21
How much are these statements true for you?	music reading strategies	23
How much do you like the different parts of music lesson in your elementary school?	attitude towards music reading	22
How much do you agree with the following statements in connection to your music lesson?	attitude towards music reading	21
How much do you like singing?	attitude towards music performance	19
How do you like the following subjects if you study in a music school?	attitude towards music lessons	20
What were your last grades in the music schools?	music school achievement	24
What were your last grades in your primary school?	school achievement	24
In what orchestra/ choir are you in a member?	functional music literacy	12
How many times do you perform?	functional music literacy	13,14,15
How much do you like to perform?	functional music literacy	16, 17, 18
Are you planning a musical future?	school continuation decision (motivation)	32
Do you have the possibility to use Internet?	digital/ technological literacy	26
Do you have a computer/ laptop at home?	digital/ technological literacy	25
How much time spent on Internet?	digital/ technological literacy	27
How much do you like going to school?	attitude	29
What do you like to do in your free time?	music preference	33
How much do you like reading?	attitude toward reading	36
How much are you confident with your school achievement?	school achievement	30
How much do you like to go to school?	attitude	16
What is the highest degree you would like to reach?	school continuation decision	31
How much do you like the following subjects?	attitude towards general subjects	20
What is your opinion about the difficulty of the test?		1

7. Testing the music reading skills of music school students

7.1. Study 4. Pilot online music reading test in music schools

To my knowledge, no technology-based online assessment has tested music reading skills of students in spite of its importance in music education in Hungary. With the help of an online test, the characteristics and the developmental trends of music reading skills can be examined by comparing the achievements of the age groups.

Music reading skills of music school students were examined to answer the following research questions:

1. Is our online music reading test reliable?
2. What is the music reading achievement-level of students' performance in music schools?
3. What are the levels of the different areas of students' music reading?

7.2. Methods

7.2.1. Participants

Participants were tested in the fall of 2015. A total of 107 music school students from five consecutive grades participated in Study 4 (Table 11). Students were selected from two music schools, located in Szeged and Abony. All the students, aged between 9-14 years, have various opportunities for practicing music reading in music schools, such as orchestra, chamber groups, or solfege lessons. All students study a musical instrument twice a week.

Table 11 The sample of Study 4

Grade	*N*	*Boys (%)*	*Girls (%)*
4	28	21.43	78.57
5	27	40.74	59.26
6	20	30.77	69.23
7	20	30	70
8	21	10	90
Total	107	26.58	73.42

7.2.2. Instruments

Participants completed the online music reading test described in chapter 6. The test consisted of four subtests with 55 multiple-choice closed questions. Each appropriate response was awarded one point, with a maximum possible test score of 55. The results and were imported from the eDia platform for statistical analyses. The tasks of the test can be found in Appendix A.

7.2.3. Procedures

As the Hungarian music schools do not have computer rooms, on my prior request solfege room were equipped with computers. Participants were assessed in a solfege room at the music schools during school hours. During the testing process, each student worked on a separate computer or tablet in their own school. Before the testing process, permissions were obtained from the participating schools. Students were not required to put their names on the survey to assure the anonymity of all participants. The volunteering schools were given a passcode to be able to log into the eDia platform, where the music reading test could be accessed. Students read the instructions on the computer screen and received musical audio stimuli through headsets. There was no time limit for the individual tasks, and students were allowed to return to the previous items. Students had one hour to go through all the tasks. The time limit proved to be enough. Data processing was performed with the use of the SPSS 21 software.

7.3. Results

The music reading test proved to be reliable, with a Cronbach's alpha of 0.858. The melody reading subtest with 25 items proved to the most reliable (Cronbach's alpha=0.759). The musical concepts and signs subtest has the lowest reliability (Cronbach's alpha=0.536), due to the smaller number of items (5 items). Table 12 summarizes the reliabilities of the music reading test and its subtests by grade.

Table 12 The reliabilities of the online test of music school students by grade (Cronbach's alpha)

Grade	*The whole test*	*Rhythm reading*	*Melody reading*	*Musical concepts and signs*	*Aural skills*
4	0.819	0.656	0.753	0.445	0.617
5	0.894	0.769	0.781	0.670	0.803
6	0.809	0.589	0.729	0.274	0.312
7	0.881	0.708	0.661	0.434	0.592
8	0.873	0.777	0.779	0.567	0.728
Total	0.858	0.710	0.759	0.536	0.763

The results indicate that the difficulty of the test fit the ability range of students. Even the youngest students performed fairly well on the test, and no ceiling effect was experienced even in the oldest group from the music school (Table 13).

Table 13 Descriptive statistics of the music reading test by grade (%p)

Grade	*Mean*	*SD*
4	60.24	13.24
5	60.74	16.31
6	69.09	11.29
7	67.40	14.83
8	66.13	15.99
Total	63.11	16.43

An ANOVA was conducted to compare the results of different age groups. No significant difference was found between their performances (F=1.331, p=0.265).

While rhythm reading tasks proved to be the easiest for students, the tasks testing their audiation were more difficult for them. Almost all students solved tasks 18 and 19 on music clefs, even C-clef (t20) and more than 90% of them recognized the G note (t21). 94% of them were familiar with the syncopation, around 80% of the students answered correctly to the questions in the tasks with simple time signatures (t11, t14 and t15). Music school students knew the hand signs (t54) very well. However, identifying major, minor or diminished triads was the most difficult for the students (t30, t40 and t51). The most difficult rhythm reading task was to recognize a compound metrum (6/8) on the basis of a two-bar rhythm exercise (t4). Less than 40 per cent of students recognized it. Although the teaching of the music scales plays an important role in the music core curriculum, identifying a seven-tone modal scale, the Dorian scale (t33) was also problematic for students, as less than 40% of students gave a correct answer.

Following the examination of descriptive statistical data and the frequencies of the different items, an item analysis was performed by examining corrected item-total correlations. This value indicates how each item correlates with the rest of item. On a sample of 103 students, the reliability and the validity of the items with values under 0.194 are problematic (Everitt, 2002). The items whose values are near the critical value are further examined. Item-deleted reliability presents the value that Cronbach's alpha would be if that particular item was deleted from the scale. It can be seen that removal of any task, except t36, would result in a lower Cronbach's alpha. Removal of t36 would lead to a small improvement in Cronbach's alpha, and we can also see that the Corrected Item-Total Correlation value was low (0.112) for this item.

Even though some items were in the vicinity of this critical value (e.g., t24, t26, and t38) the instrument does not appear to suffer from low item-total correlation values, thus it can be claimed that the entire instrument yields valid results. The descriptive statistics of the tasks of the music reading test is displayed in Appendix E.

The means of two music reading subtests, i.e. music concepts and signs on the one hand, and melody reading on the other, were very close to each other, around 60%. The results necessitate more practice in solfege lessons. The results displayed in Table 14 show an overview of the means and standard deviations for each subtest of the music reading tasks.

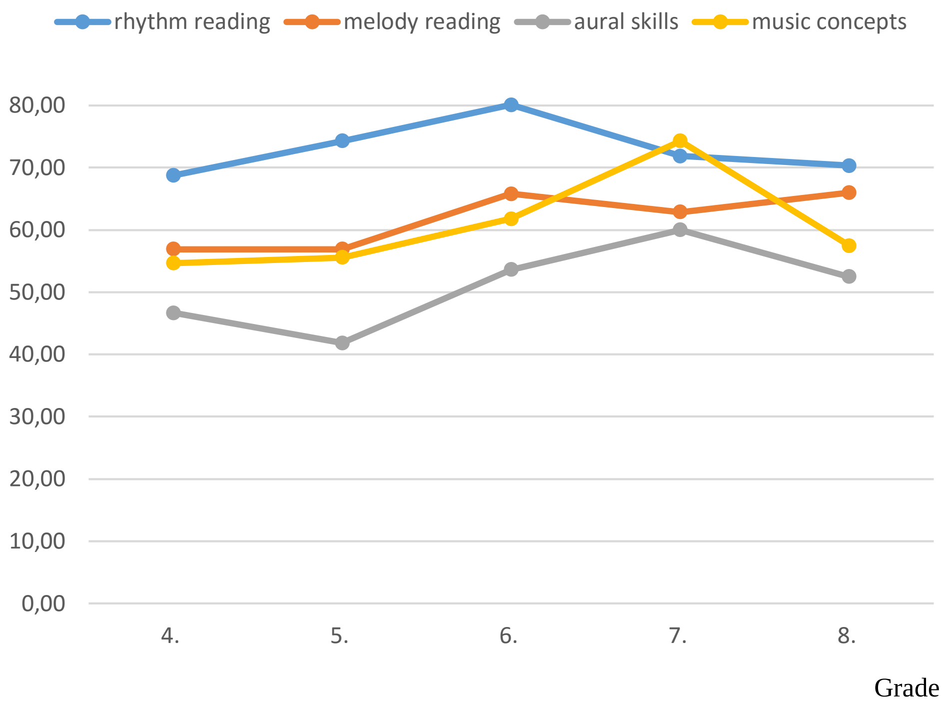
Table 14 Descriptive statistics of the music reading subtests (%p)

Subtest	*M*	*SD*
Rhythm reading	72.43	18.50
Melody reading	59.73	15.54
Aural skills	48.67	23.94
Music concepts and signs	59.11	26.80

Students' performances on the musical subtests were examined with the use of ANOVA. In the rhythm reading (F=0.865, p=n.s.), melody reading (F=1.381, p=n.s.), audiation (F=1.594, p=n.s.) and music signs and concepts (F=1.517, p=n.s.) subtests no significant differences were found between the grades.

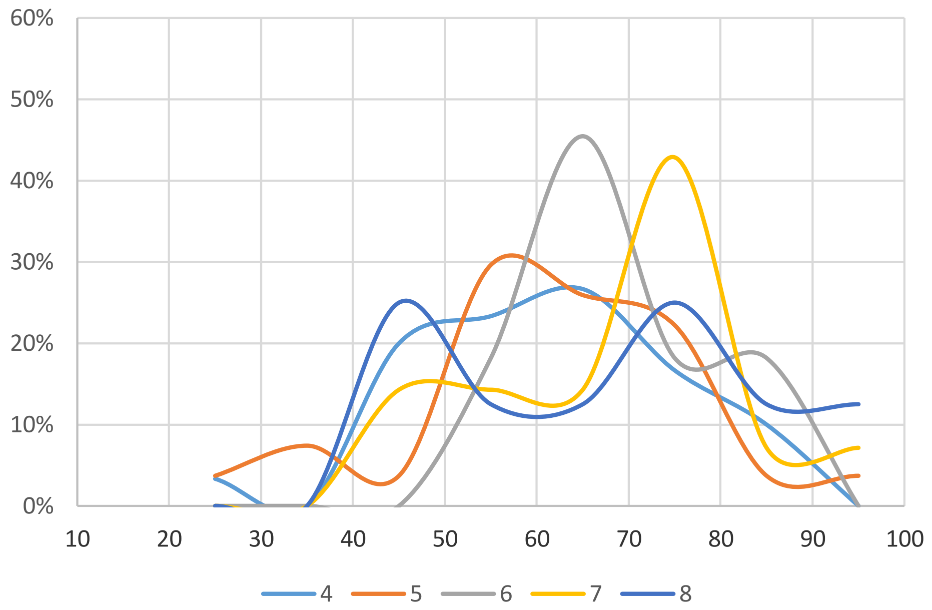
The achievements of music school students' in the subtests by grade are illustrated in Figure 54. A steady development of skills can be observed in the four examined areas of music reading skills; in rhythm reading, melody reading and musical concepts and signs subtests until the sixth grade. According to the results, students performed best on the rhythm reading subtest in all grades. Sixth grader music school students' rhythm reading achievement is the highest, 80%p. Students' performance is poorer in aural skills.

Fig. 54 The achievements in the different types of the music reading test by grade (%p)



The spread of a normal distribution is controlled by the standard deviation. Despite of the small sample, some conclusions can be drawn on the basis of the distribution curves by grades. The fourth and fifth graders' distribution curves lie more to the left, while those of the sixth and seventh graders lie more to the right of the mean, so they did not run into difficulties with the test. Their achievement is high, 40% of them has achieved around 80% in the test. The eighth graders' results show asymmetric and bimodal distribution (Figure 55). None of the eighth-graders achieved worse, than 45%. Normal distribution is observed best in the fourth grade, where the pupils achieved around 60% in the music reading pilot test.

Fig. 55 The distribution of the music reading performance by grade (%p)



7.3.1. The results of the rhythm reading subtest

The rhythm reading skills of music school students were examined with 16 items. The rhythm exercises are period-like and contain mainly four and eight bars. The results of the rhythm reading tasks are summarized by grade in Table 15.

Our analysis shows that most music school students can identify syncopation in an eight-bar musical example (t6), and also it was easy for them to recognize a popular melody from its rhythm (t16). To divide a four beat rhythm into 2/4 bars was also easy for the students, with 82% knowing the correct answer. However, the music school students ran into difficulties in identifying 6/8 time signatures on the basis of an eight-bar rhythm exercise (t4). Significant difference was found only in this task between the fifth and sixth grades ($t=2.94$, $p<0.005$). Dividing a musical exercise into 4/4 bars (t13) was also more difficult in all the grades (Mean=60%p, Standard Deviation=49.3%p).

Table 15 Mean and standard deviation achievements of the rhythm reading items by grade (%p)

Task	*Grade 4*		*Grade 5*		*Grade 6*		*Grade 7*		*Grade 8*	
	M	SD	M	SD	M	SD	M	SD	M	SD
t01	66.67	47.95	77.78	42.37	81.82	40.45	78.57	42.58	87.50	35.36
t02	60.00	49.83	73.18	40.31	72.73	46.71	57.14	51.36	62.50	51.75
t03	70.00	46.61	81.48	39.58	81.01	70.00	64.29	49.72	58.00	53.45
t04	23.33	43.02	18.52	30.58	63.64	50.45	57.14	39.30	60.50	53.70
t05	73.33	44.98	74.07	44.66	60.13	45.45	64.29	49.72	62.50	50.75
t06	93.33	25.37	96.30	19.25	100.00	0.00	92.86	26.73	87.50	35.36
t07	50.00	50.85	70.37	46.53	65.60	34.12	78.57	42.58	65.13	57.75
t08	63.33	49.01	51.85	50.92	63.64	50.45	57.14	52.12	37.52	51.75
t09	70.00	46.61	74.07	44.66	100.00	0.00	85.71	36.31	87.51	35.36
t10	76.00	40.68	70.07	40.12	81.82	40.43	64.29	49.72	75.00	46.29
t11	80.00	41.68	77.78	42.37	90.91	30.15	80.71	39.37	84.50	35.36
t12	76.67	43.02	81.48	39.58	80.02	41.46	71.43	46.88	62.50	50.70
t13	60.00	49.83	62.96	49.21	63.64	50.45	57.14	51.36	50.00	53.45
t14	73.30	44.98	81.48	38.50	90.91	30.15	86.12	32.31	75.00	42.29
t15	83.33	37.90	92.59	26.69	81.89	43.40	71.43	46.88	76.02	46.20
t16	76.60	43.02	96.30	19.25	100.00	0.00	78.57	42.58	100.00	0.00

7.3.2. Results of the melody reading subtest

In all five grades the tasks with the three musical clefs (t18, t19, and t20) proved to be the easiest for music school students. Also students had no problems with recognizing the G note (t21). All of the eighth graders knew the answers to these four tasks. Task 54 contains an exercise where a folk song had to be recognized from hand signs. 88% of the students managed to solve the task (SD=32.9). Recognizing triads in root positions (t30 and t51) was the most difficult for the students. Only about the 10 per cent of the fourth and fifth graders were able to find the major triads. Task 26 proved to be as difficult as the previous one, where only 34% of the students succeeded in identifying the tonality of a four-bar melody (d-minor), while 56% of the students knew the D-major tonality. With the use of variance analysis a significant difference was found between the sixth and eighth grades in task 27 (F=2.282, p=0.032). 100% of the eighth graders knew the right answer, i.e. the perfect fifth interval (Table 16).

Table 16 Mean achievements and standard deviations of the melody reading items by grade (%p)

Task	*Grade 4*		*Grade 5*		*Grade 6*		*Grade 7*		*Grade 8*	
	M	SD	M	SD	M	SD	M	SD	M	SD
t18	96.67	18.26	100.00	0.00	100.00	0.00	92.86	26.73	100.00	0.00
t19	93.33	25.37	100.00	0.00	100.00	0.00	100.00	0.00	100.00	0.00
t20	94.12	20.32	96.30	19.25	81.82	41.00	85.71	36.31	100.00	0.00
t21	94.38	26.34	92.59	26.69	83.22	40.45	92.86	26.73	100.00	0.00
t22	63.32	49.01	72.37	46.53	90.91	30.15	81.71	36.31	86.20	35.36
t23	73.33	44.98	69.17	40.13	72.73	46.71	92.86	26.73	87.50	30.01
t24	60.13	40.51	62.96	49.21	80.83	42.45	78.57	42.58	75.60	46.29
t25	46.67	50.74	44.44	50.64	72.73	46.71	71.43	46.88	72.10	43.22
t26	20.00	40.68	37.04	49.21	36.36	50.45	56.10	51.36	37.50	51.75
t27	64.34	49.01	88.89	32.03	81.82	41.42	57.14	43.39	100.00	0.00
t28	70.00	46.61	70.37	46.53	72.73	46.71	42.86	32.36	75.00	46.29
t29	30.00	47.68	51.85	50.92	83.82	48.25	50.00	51.89	62.50	50.75
t30	6.67	25.37	11.11	32.03	35.45	52.22	14.29	36.31	37.50	51.75
t31	43.33	50.40	40.74	50.07	82.90	39.40	71.43	46.88	75.00	46.29
t33	36.67	49.01	22.22	42.37	54.55	52.22	50.00	51.89	35.50	54.70
t34	73.14	42.18	70.37	46.53	85.10	40.45	100.00	0.00	87.50	35.36
t45	90.00	30.51	81.48	39.58	82.10	45.45	78.57	42.58	62.50	51.75
t46	92.40	36.59	77.78	42.37	100.00	0.00	92.86	26.73	75.00	46.29
t51	36.67	49.01	29.63	46.53	45.45	52.22	42.86	51.36	62.50	51.75
t53	86.67	34.57	70.37	46.51	72.73	46.71	71.43	46.88	73.00	43.29
t54	83.33	37.90	85.19	36.20	100.00	0.00	92.86	26.73	84.50	30.36

7.3.3. Results of the aural skills subtest

The students in all grades ran into difficulties with identifying the brass orchestra. The fourth graders achieved the best results in task 37. This is not surprising, because they learn about the different types of orchestra in this grade. Task 38, where the students were supposed to find out which wind instrument they were listening to, was problematic for them as well. The wind instruments, e.g. the clarinet, flute or oboe, are part of the curriculum in the fourth grade. Distinguishing perfect intervals and recognizing a minor triad posed a problem to the students in all the grades. Recognizing the tone of a mixed choir (t52) was the easiest, with no significant differences between the different grades. The results of the tasks of audiation are presented in Table 17.

Table 17 Mean achievements of the aural items by grade (%p)

Task	*Grade 4*		*Grade 5*		*Grade 6*		*Grade 7*		*Grade 8*	
	M	SD	M	SD	M	SD	M	SD	M	SD
t37	40.00	49.83	22.22	42.37	18.18	40.45	28.57	46.88	25.00	46.29
t38	56.67	50.40	25.93	44.66	36.36	50.45	50.00	51.89	62.50	51.75
t39	23.33	43.02	14.81	36.20	19.28	40.45	25.57	49.88	37.50	51.75
t40	30.00	46.61	18.52	39.58	27.27	46.71	42.86	51.36	50.00	53.45
t41	64.67	47.90	66.67	48.04	81.82	42.45	78.57	42.58	67.51	51.75
t42	73.33	44.98	59.26	50.07	90.91	30.15	92.86	26.73	62.50	51.75
t43	66.67	47.95	51.85	50.92	54.55	52.22	78.57	42.58	61.50	51.75
t47	36.67	49.01	44.44	50.64	27.27	46.71	50.00	51.89	50.00	53.45
t48	33.33	47.95	40.74	50.07	72.73	46.71	57.14	51.36	37.50	51.75
t49	40.00	49.83	62.96	49.21	63.64	50.45	64.29	49.72	50.10	53.45
t52	60.00	49.83	59.26	50.07	90.91	30.15	92.86	26.73	87.50	35.36

7.3.4. The results of the musical concepts and signs subtest

Although the musical period is the most common musical form, only 30% of the music school students were familiar with it. The term *Allegro* is almost the most frequently used word in music instruction; however, only 44% of the music school students knew the correct answer, and the eighth graders had the poorest result (37.50 %). 61% of the students recognized the decrescendo sign. The F-values of the analysis of variance were also examined. No significant differences were observed between the results of the five grades. The results of the tasks of the musical concepts and signs subtest are presented in Table 18.

Table 18 Mean achievements of the musical concepts and signs items by grade (%p)

Task	*Grade 4*		*Grade 5*		*Grade 6*		*Grade 7*		*Grade 8*	
	M	SD	M	SD	M	SD	M	SD	M	SD
t32	73.33	44.98	59.26	50.07	54.55	52.22	57.14	51.36	87.50	35.36
t35	86.67	34.57	81.48	39.58	63.64	50.45	85.71	36.31	75.00	46.29
t36	60.00	49.83	44.44	50.64	36.36	50.45	42.86	51.36	37.50	51.75
t44	23.33	43.02	18.52	39.58	36.36	50.45	57.14	51.36	37.50	51.75
t50	43.33	50.40	40.74	50.07	54.55	52.22	50.00	51.89	37.50	51.75
t55	46.67	50.74	66.67	48.04	72.73	46.71	78.57	42.58	50.00	53.45

7.3.5. Summary

The online music reading test was judged to be suited for data collection after being piloted. The results indicate that the difficulty level was appropriate for the chosen age groups. The reliability of the music reading test proved to be good, with a Cronbach's alpha of 0.858. The whole test and its subtests are the most reliable in grade 6. No significant difference was found between the grades neither in the whole test, or in its subtest. Sixth graders achieved the best results in the music reading test. In music schools it is the last grade, in which students study solfege compulsorily.

Students' achievement level was the best in the rhythm reading subtest. The pattern of syncopation was recognized by almost every student. Even fourth graders did not run into difficulties with reading more complex rhythmic patterns. However, identifying simple metres (2/4 and ¾) and symmetrically compound metres (4/4, and 6/8) posed problems to the students in every grade.The majority of students (even the fourth graders) knew the correct answer to the questions about musical signs and concepts, which demonstrates that students are familiar with the basic music theoretical concepts from the fourth grade.

The tasks of the aural skill subtest proved to be the most difficult for students. This fact is surprising, because aural skills can improve in non-musical context as well. These skills play a crucial role in reading. On the basis of the results, it can be concluded that more focused development is needed in the field of audiation.

7.4. Study 5. Large-scale assessment of music reading skills in music schools

Having piloted the online test, a large-scale assessment was conducted in music schools in order to map students' music reading skills and reveal correlations about certain background variables. As described in detail in chapter 6, the online test was administered through the eDia assessment platform in connection with music reading skills of music school students. The following research questions are addressed:

1. How reliably does the online music reading instrument assess music reading skills among music school students?
2. What is the music reading level of the students?
3. Do visual-spatial skills correlate with music reading skills?
4. How does the achievement of the students correlate with certain background variables?

7.4.1. Methods

7.4.1.1. Participants

In the large-scale assessment the sample was selected with the help of the coordinators of the Institute of Education, University of Szeged. The Institute submitted a request to a number of music schools in Hungary which agreed to involve their students in the research. The sample consist of 10-14 year-old students (N=160) from five music schools. Table 19 displays the locations of the participating schools.

Table 19 The number of the students from the participating music schools in the different towns

Municipality	*Number*
Budapest	18
Szeged	25
Kecskemét	65
Törökszentmikós	38
Abony	14
Total	160

Participants were 160 Hungarian 5th-8th graders; all of them study a musical instrument twice a week (Table 20).

Table 20 The sample of Study 5

Grade	*N*	*Gender*	
		Girls (%)	Boys (%)
5	37	64.84	35.13
6	43	60.47	39.53
7	38	52.64	47.36
8	42	38.10	61.90
Total	160	60,00	40,00

7.4.1.3. Instruments

Three instruments were used in the study: 1) the online music reading test comprising four subtests with 55 items to map the music reading skills of the students can be found in Appendix A. Each item was worth one point with a maximum possible score of 55 points. The online test was judged to be suited for data collection after being piloted. 2) The online map reading test is presented in Appendix B. 3) The online background questionnaire is presented in Appendix C.

7.4.1.4. Procedures

The procedure of the research was the same as in Studies 4. The participating schools were given a passcode to be able to log into the eDia platform, where the music reading test and the background questionnaire could be accessed. The survey guideline for the music teachers helping in the organization of the research of the music reading test can be found in Appendix D. However, during our research we encountered the problem music schools not having computers, so we needed to conduct the survey in person with the use of tablets. Data were gathered in January 2016. It took approximately 50 minutes to take the music reading test, while completing the online questionnaire took 15 minutes.

7.4.2. Results

As it was discussed in chapter 6, the music reading test contained 55 tasks. The reliability of the test battery proved to be good (Cronbach's alpha=0.832). Mainly because of the larger sample, the reliability of each subtest proved to be better than in the pilot study. The test proved to be the most reliable in the fifth grade (Cronbach's alpha=0.865). The least reliable was the test in the sixth grade (Cronbach's alpha=0.807) (Table 21).

Table 21 The reliabilities of the music reading test and its subtests of music school students by grade (Cronbach's alpha)

Grade	*The whole test*	*Rhythm reading*	*Melody reading*	*Aural skills*	*Musical signs & concepts*
5	0.865	0.719	0.761	0.572	0.623
6	0.807	0.704	0.685	0.382	0.532
7	0.814	0.715	0.694	0.436	0.498
8	0.823	0.785	0.746	0.433	0.437
Total	0.832	0.734	0.718	0.506	0.521

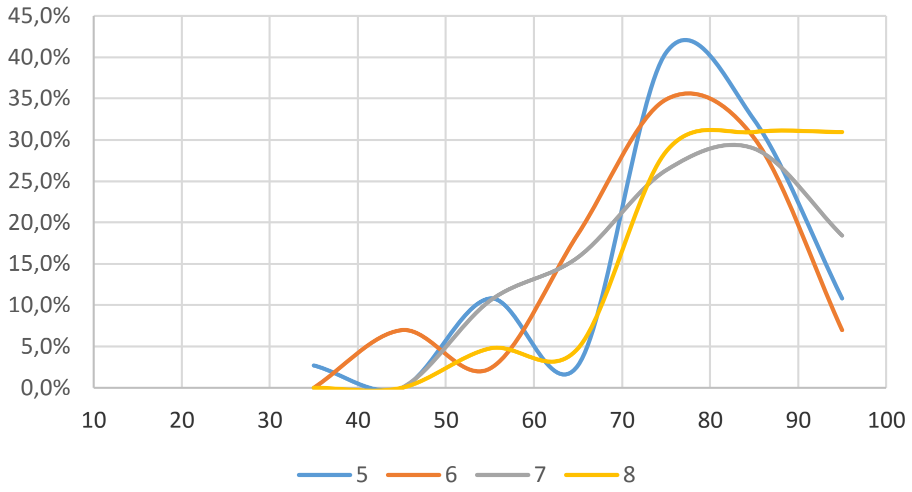
The test fits to the difficulty of the development level of the grades assessed. Students' achievement was 76.69%, with a standard deviation of 12.35. According to the results of variance analysis, (F=4.206, p=0.007) significant differences were found between the sixth and eighth school grades. In Table 22 the descriptive statistics of the online test are shown.

Table 22 Descriptive statistics of the online music reading test by grade (%p)

Grade	*N*	*Mean*	*SD*
5	37	75.09	13.84
6	43	73.07	11.61
7	38	76.94	11.47
8	42	81.60	11.18
Total	160	76.69	12.35

No students got top scores in the music reading test. The distribution curves of each grade are located to the right of the mean (Figure 56). This means that the music reading test proved to be easy for the music students. Multimodal distribution curves are observed in all grades. Only the fifth graders achieved worse results than 35%, and around 10% of the students in all grades who performed lower than 50%.

Fig. 56 The distribution of music reading performance by grade (%p)



As the music reading test and its subtests strongly correlate with each other, it can be concluded that the measured skill structure is homogeneous (Table 23). The strongest correlations were found between students' music reading achievement and the melody reading subtest. I performed a linear regression analysis with students' music reading score as the dependent variable and the students' achievements of the subtests as independent variables. The rhythm reading subtest explained 36.5% of variance, the melody reading subtest explained 27.5% of variance in the music reading test score. The aural skill subtest explained 18.2% of variance, whereas musical concepts and signs explained 15.9% of variance in the music reading achievement.

Table 23 Intercorrelations between music reading test, the subtests and the map reading test

	The whole test	*Rhythm*	*Melody*	*Aural skills*	*Concepts and signs*
Rhythm	0.851**				
Melody	0.875**	0.607**			
Aural	0.507**	0.292**	0.356**		
Concepts and signs	0.663**	0.458**	0.523**	0.278**	
Map reading	0.536**	0.389**	0.389**	0.178**	0.250**

Note: *p<0.05; **p<0.001

The level of difficulty of the online tasks can be examined by the means and the corresponding standard deviation values. We can observe a higher achievement for the rhythm reading, than for melody reading. Significant differences were found in the achievement of the subtests; aural skills / audiation and music concepts and signs. In Table 24 the descriptive statistics of the subtests are presented.

Table 24 Descriptive statistics of the music reading test

		Grade 5	*Grade 6*	*Grade 7*	*Grade 8*	*F*	*Sign.*
Rhythm reading	M	80.74	76.89	81.74	85.57	2.03	n.s.
	SD	16.03	16.39	16.40	16,42		
Melody reading	M	82.37	80.89	82.84	85.92	0.99	n.s.
	SD	15,60	12.94	13.25	13.57		
Aural skills	M	60.00	57.67	62.11	71.43	4.89	p<0.01
	SD	20.41	16.59	17.73	15.86		
Music concepts	M	68.650	70.23	79.47	85.71	4.782	p<0.01
	SD	28.496	30.76	18.88	17.82		
Visual/ spatial	M	53.70	55.04	65.79	69.84	2.92	n.s.
	SD	34.06	30.76	28.46	24.20		

The students' performance in the music reading test is demonstrated in Appendix F. Identifying musical clefs, note names and the perfect intervals proved to be the easiest for students. They had no difficulty with syncopation or recognizing a song by its notation. The most difficult task was identifying the 6/8 meter, which is not common in Hungarian folk music, so the relative difficulty of identifying it was in accordance with assumptions. Finding the four major triads was the second most difficult task in the entire test.

7.4.2.1. The results of the rhythm reading subtest

Table 25 presents the results of the tasks in rhythm reading. The mean is high: 81.21%, with an SD of 16.47. Students had the highest achievement in syncopation. Dividing a music sample into 3/4 bars also proved to be easy for the learners (92%). They were able to recognize a song by its rhythm. It can be expected that the students are familiar with the most frequent 2/4 meter. Identifying the 6/8 meter proved to be the most difficult in the whole task (36%), which may be due to its rare occurrence in Hungarian music. The performance of the students in tasks with simple meter (t3, t4) is close to the mean.

Table 25 Descriptive statistics of the rhythm reading test (%p)

Task	*Mean*	*SD*
t06	95	21.9
t15	92	27.4
t16	91	28.3
t12	89	31.4
t05	88	32.5
t14	88	33.2
t01	87	3.39
t11	86	3.45
t02	83	3.76
t03	82	3.86
t10	80	4.01
t09	79	4.10
t13	78	4.15
t07	77	4.23
t08	69	4.62
t04	36	4.80

The results of the rhythm reading tasks are summarized in Table 26. The mean of the tasks are around 80 percent; however, no one had 100% in the different tasks. The sixth graders had the best results, with 97.67% being familiar with syncopation (t6). Furthermore, it was easy for them to recognize a popular melody from its rhythm (t16), 97.62% of the eighth graders gave a correct answer. Dividing a rhythm exercise into 3/4 bars (t14) was also easy for the students, with about 90% knowing the right answer. Just like in the pilot study, the music school students had difficulties in identifying 6/8 time signatures (t4). A significant difference was found in this task between both the sixth and seven, and the sixth and eighth grades ($F=8.343$, $p=0.004$). Identifying the quarter rest caused a difficulty in the sixth grade, where 60% of students knew the right answer.

Table 26 The mean values of each rhythm reading task by grade (%p)

Task	*Grade 5*		*Grade 6*		*Grade 7*		*Grade 8*	
	M	SD	M	SD	M	SD	M	SD
t01	89.19	31.48	81.40	37.87	81.58	39.29	95.24	21.55
t02	81.08	39.71	82.40	39.37	84.21	36.95	85.71	35.42
t03	83.70	37.37	83.72	37.35	86.84	34.26	73.81	44.50
t04	27.03	45.02	11.63	32.44	50.00	50.67	54.76	50.38
t05	84.78	34.37	88.37	30.40	86.01	34.26	93.86	26.07
t06	94.59	22.92	97.67	15.25	94.74	22.63	92.86	26.07
t07	78.38	41.73	74.42	44.15	81.58	39.29	73.81	44.50
t08	70.27	46.34	60.47	49.47	68.42	47.11	78.57	41.53
t09	82.78	39.37	72.09	45.39	76.32	43.09	83.33	37.72
t10	89.19	31.48	76.74	42.75	74.02	41.09	78.57	41.53
t11	85.79	31.31	83.00	39.37	84.21	36.95	95.24	25.50
t12	89.19	31.48	81.40	30.37	89.47	31.10	95.24	21.55
t13	67.86	48.40	79.07	40.10	78.95	42.32	88.10	32.78
t14	64.86	40.48	78.37	41.16	77.11	49.32	86.11	39.78
t15	91.89	27.67	86.05	35.06	94.74	22.63	95.24	21.55
t16	94.59	22.92	88.37	32.44	84.21	36.95	97.62	15.43

7.4.2.2. The results of the melody reading subtest

The students' performance in the melody reading tasks (M=79.28%, SD=13.99) was good. Knowing musical clefs is essential for music reading. Every music school student managed to identify the G-clef. Almost all of them knew F- and C-clefs and identified the perfect fifth interval. More than 90% of the students were able to recognize songs by their notation. The students succeeded in determining d-minor tonality in a musical score (t25) and identifying major triads (t29**),** close to the average of melody reading tasks**.** The two music reading tasks (task 30 and 35), in which they had to identify major and minor triads and determine a folksong's scale by its notation, were the most difficult for them. Table 27 shows the descriptive statistics of the items in the test.

Table 27 The descriptive statistics of the melody reading test (%p)

Task	*Mean*	*SD*
t18	100	0.0
t19	97	15.7
t27	97	17.5
t20	97	17.5
t21	95	21.9
t46	95	21.9
t45	89	30.9
t23	89	31.7
t22	88	33.2
t24	82	38.6
t51	81	39.6
t31	81	39.6
t25	79	41.0
t29	68	46.7
t32	66	47.4
t33	53	50.1
t36	46	50.0
t30	42	49.5

Students achieved 100% in six tasks of the melody reading subtest. In all the five grades the tasks with the three musical clefs (tasks 18, 19, and 20) proved to be the easiest for music school students, similar to the pilot study. Also, students had no problems with recognizing the G note (t21). Task 53 contains letter notation. 92% of the fifth graders and 88% of the eighth graders knew the correct answer. Recognizing four major triads in root positions (task 30) was the most difficult for the students: 51.35% of the fifth grader music school students and 45.24% of the eighth graders identified them. With the use of variance analysis, a significant difference can be observed between the achievements of the fifth, sixth and eighth graders on task 33 ($F=5.308$; $p=0.032$) dealt with a modal scale. All of the fifth and sixth graders gave the correct answer to the task 27, i.e. the perfect fifth interval (t27).

On the other hand, the tasks, where students were supposed to identify the tonality of a melody, proved to be difficult. Only 30% of the sixth graders succeeded in identifying the pentatonic scale, while 50% of the seventh graders recognized the tonality.

The mean values of each melody reading task can be seen in Table 28.

Table 28 Mean achievements of the melody reading items by grade (%p)

Task	*Grade 5*		*Grade 6*		*Grade 7*		*Grade 8*	
	M	SD	M	SD	M	SD	M	SD
t18	100.00	0.00	100.00	0.00	100.00	0.00	100.00	0.00
t19	97.30	10.44	97.67	10.25	100.00	0.00	95.24	21.55
t20	98.30	16.41	96.67	15.25	100.00	0.00	92.86	26.07
t21	100.00	0.00	88.37	32.44	94.74	22.63	97.62	15.43
t22	86.49	34.66	83.72	37.35	92.11	27.33	88.10	32.78
t23	83.78	37.37	81.40	39.37	92.11	27.33	97.62	15.43
t24	78.38	41.73	90.70	29.39	78.95	41.32	78.57	41.53
t25	75.68	43.50	79.07	41.16	78.95	37.00	80.95	39.74
t26	59.46	49.77	67.44	47.41	63.16	48.89	73.81	44.50
t27	89.19	31.48	100.00	0.00	100.00	0.00	97.62	15.43
t28	72.97	45.02	62.79	48.91	60.53	49.54	76.19	43.11
t29	62.16	49.17	83.72	37.35	71.05	45.96	83.33	37.72
t30	51.35	50.67	39.53	49.47	31.58	47.11	45.24	50.38
t31	72.97	45.02	81.40	39.37	84.21	36.95	83.33	37.72
t33	70.27	46.34	30.23	46.47	50.00	50.67	61.90	49.15
t36	54.05	50.52	37.21	48.91	52.63	50.60	42.86	50.09
t43	86.49	34.66	67.44	47.41	71.05	45.96	76.19	43.11
t44	43.24	50.22	62.79	48.91	65.79	48.08	57.14	50.09
t45	89.19	31.48	81.40	39.37	92.11	27.33	95.24	21.55
t46	62.16	49.17	67.44	47.41	73.68	44.63	71.43	45.72
t50	70.27	46.34	58.14	49.92	63.16	48.89	88.10	32.78
t51	67.57	47.46	86.05	35.06	76.32	43.09	90.48	29.71
t53	91.89	27.67	93.02	25.78	94.74	22.63	88.10	32.78
t54	83.72	37.35	83.72	37.35	89.47	31.10	95.24	21.55

7.4.2.3. The results of the audiation subtest

Almost 100% of the eighth graders made the correct choice between the notations after listening to their melody (t42). Significant differences were found between the sixth and eighth grades ($F=4.945$, $p=0.003$).

Recognizing the timbre of a mixed choir (t52) was one of the easiest, 92.5% of the eighth graders gave the correct answer. The seven graders achieved the best results on task 37 (55.26%), where they had to choose between the different types of orchestra. However, task 39, where the students were supposed to find out which interval they were listening to, was challenging for them. Only 23.26% of the sixth graders recognised the perfect fourth interval. With the use of variance analysis, a significant difference can be observed between the achievements of the sixth and eighth graders on task 39 (F=4.297, p=0.006). The mean values of each audiation task can be seen in Table 29.

Table 29 Mean achievements of the audiation items by grade (%)

Task	*Grade 5*		*Grade 6*		*Grade 7*		*Grade 8*	
	M	SD	M	SD	M	SD	M	SD
t37	37.84	49.17	44.19	50.25	55.26	50.39	52.38	50.55
t38	45.95	50.52	55.81	50.20	36.84	48.89	42.86	50.09
t39	48.65	50.60	23.26	42.75	39.47	49.54	59.52	49.68
t40	51.35	50.67	41.86	49.92	39.47	49.54	64.29	48.50
t41	59.46	49.77	60.47	49.47	71.05	45.96	90.48	29.71
t42	78.38	41.73	74.42	44.15	94.74	22.63	97.62	15.43
t43	86.49	34.66	67.44	47.41	71.05	45.96	76.19	43.11
t47	45.95	50.52	55.81	50.25	47.37	50.60	54.76	50.38
t48	59.46	49.77	53.49	50.47	57.89	50.04	66.67	47.71
t49	62.16	49.17	67.44	47.41	73.68	44.63	71.43	45.72
t50	70.27	46.34	58.14	49.92	63.16	48.89	88.10	32.78
t52	83.78	37.37	76.74	42.75	86.84	34.26	92.86	26.07

7.4.2.4. The results of the music concepts and signs subtest

This subtest contains only five tasks. The eighth graders had the best achievement in four of them. 88.10% of the eighth graders knew what allegro means. A significant difference was found between the results of the sixth, seventh and eighth graders (F=5.266; p=0.002). 90% of the eighth graders managed to identify the cello, as 58.38% learned about it in the sixth grade. A significant difference can be observed between the achievements of the sixth and eighth graders on task 50 (F=3.562; p=0.016). With the use of variance analysis, a significant difference can be observed between the achievements of the fifth, sixth and eighth graders on task 55 (F=5.002, p=0.002), as well, where students were asked to identify a dynamic sign. The mean values by grades of the subtest are presented in Table 30.

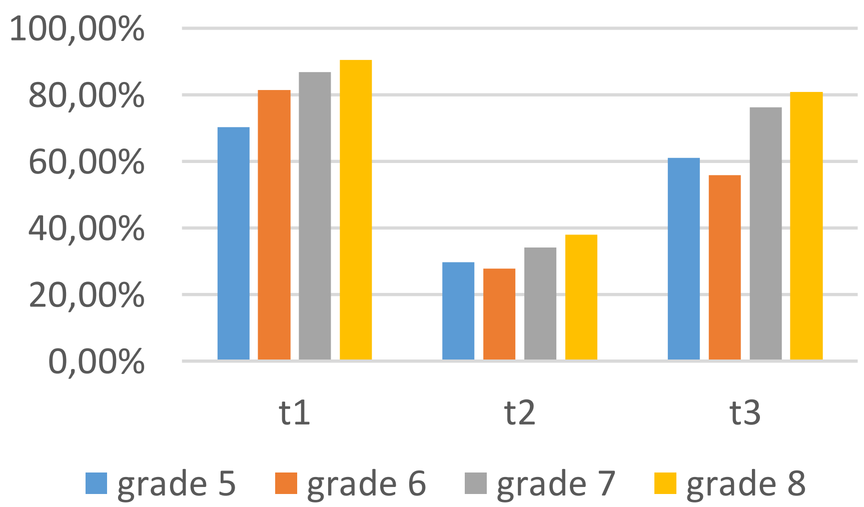
Table 30 The mean achievements of the tasks of the music concepts and signs by grade (%p)

Task	*Grade 5*		*Grade 6*		*Grade 7*		*Grade 8*	
	M	SD	M	SD	M	SD	M	SD
t32	62.16	49.17	72.09	45.39	65.79	48.08	64.29	48.50
t35	78.38	41.73	67.44	47.41	92.11	27.33	95.24	21.55
t44	43.24	50.22	62.79	48.91	65.79	48.08	57.14	50.09
t50	70.27	46.34	58.14	49.92	63.16	48.89	88.10	32.78
t55	72.97	45.02	79.07	41.16	94.74	22.63	97.62	15.43

7.4.2.5. The results of the map reading tasks

Although this test was not part of the music reading test, it can be observed that the results of the test improve with age. Music school students' achievements are good on tasks 1 and 2. Pupils in every grade had good results, over 70%. With the use of variance analysis, a significant difference can be observed between the achievements of the fifth and seventh graders on task 3 (F=3.541, p=0.014). The mean values of the test are presented in Figure 57.

Fig. 57 Mean achievements of the items of the map reading test by grade (%p)



As expected, a significant correlations were found between the performances of the music reading test and the achievement of the map reading test (r=0.364, p<0.01).

7.4.2.6. The influence of background variables on students' performance

The content of the background questionnaire is discussed in chapter 6. Our analysis gives a straightforward explanation for the results of the research and also helps to interpret the context of music education. The majority of the music school students (43.1%) found the test to be moderately difficult, whereas 31.9% of them considered it easy. A weak correlation was found between students' subjective estimation of their own performance and their actual performance on the music reading test ($r=0.214$, $p<0.05$). We found no relationship between the music reading achievement and the parents' educational level. Every mother had at least a secondary-level education (Table 31).

Table 31 The correlation between the achievement in the music reading test and maternal education by grade

	Secondary-level education		*Tertiary-level education*			
	M	SD	M	SD	t	p
Grade 5	82.10	7.92	74.21	17.69	1.4430	n.s.
Grade 6	74.79	7.92	74.37	13.28	0.1080	n.s.
Grade 7	70.33	10.45	67.41	9.12	1.2300	n.s.
Grade 8	74.91	12.49	80.61	8.86	0.2430	n.s.

A weak correlation ($r=197$, $p<0.05$) was found between the mother's educational level, and the students' achievement in the map reading test. In order to explore the influence of the socio-economic background of the students, we analyzed a number of background variables, e.g. number of books, CDs, cell phones, computers etc. However, no significant correlations were found with the music reading achievement. On the basis of the results, it can be concluded that there is no relationship between the financial background variables and the music reading performance.

7.4.2.7. Gender differences

In the music reading test the overall boys' performance was 76.90 %, ($SD=13$), while that of the girls' was 76.56%, ($SD=11.9$). An independent sample t-test was used to analyze the results of the music reading test by grade and gender. There were no significant differences between the boys' and girls' achievements on the subtests (Table 32).

Table 32 Means and standard deviations (%) by gender

Grade	*Boys*		*Girls*		*Levene*		*T-test*	
	M	SD	M	SD	F	p	t	p
5	78.70	12.62	72.89	14.35	0.925	0.54	1.249	0.220
6	69.73	10.12	75.24	13.10	5.168	0.28	-1.546	0.130
7	76.57	12.18	77.27	11.1	0.223	0.640	-1.870	0.853
8	83.80	8.58	80.56	12.57	1.817	0.185	0.766	0.448
Total	76.90	13	76.56	11.95	0.877	0.351	0.171	0.865

A significant difference was found in the boys' music reading achievement levels between the sixth and the eighth grades (F=3.063, p=0.035).

Table 33 displays the achievements of boys in rhythm reading. There were no significant differences between the boys' and girls' achievements in the rhythm reading subtest.

Table 33 Means and standard deviations (%) of the rhythm reading subtest by gender

Grade	*Boys*		*Girls*		*Levene*		*T-test*	
	M	SD	M	SD	F	p	t	p
5	84.82	10.60	79.32	12.59	1.993	0.167	1.215	0.232
6	73.16	20.81	75.24	13.10	3.043	0.089	-0.974	0.336
7	84.02	17.04	79.68	15.95	0.088	0.769	0.811	0.423
8	90.62	10.45	82.45	18.70	2.894	0.097	1.596	0.118
Total	82.98	16.59	80.00	16.37	0.157	0.693	1.125	0.262

There were no significant differences between their performances on the melody reading subtest (Table 34).

Table 34 Mean percentages, standard deviations (%) of the melody reading subtest by grade

Grade	*Boys*		*Girls*		*Levene*		*T-test*	
	M	SD	M	SD	F	p	t	p
5	80.35	14.73	77.39	14.73	0. 219	0.643	2.206	0.575
6	75.00	16.20	79.03	11.04	0.427	0.517	-0.974	0.336
7	76.94	16.63	80.5	12.23	2.167	0.150	-0.756	0.455
8	81.25	13.72	82.84	12.97	0.002	0.965	-0.388	0.700
Total	78.23	15.29	80.00	16.37	0.704	0.403	0.697	0.434

A significant difference was found between genders only in the map reading test (p<0.001) (Table 35), where the boys performed better than girls.

Table 35 Mean percentages, standard deviations (%) of the map readig test by grade

Grade	*Boys*		*Girls*		*Levene*		*T-test*	
	M	SD	M	SD	F	p	t	p
5	61.91	28.81	47.82	35.99	2.618	0.115	1.240	0.223
6	62.74	35.12	50.00	27.08	1.248	0.270	1.341	0.187
7	72.22	26.19	60.00	29.81	2.167	0.150	-0.756	0455
8	72.91	21.83	67.94	25.78	0.039	0.845	1.336	0.190
Total	67.69	28.24	56.49	30.39	2.410	0.123	2.388	0.020

7.4.2.8. The influence of music education on the test results

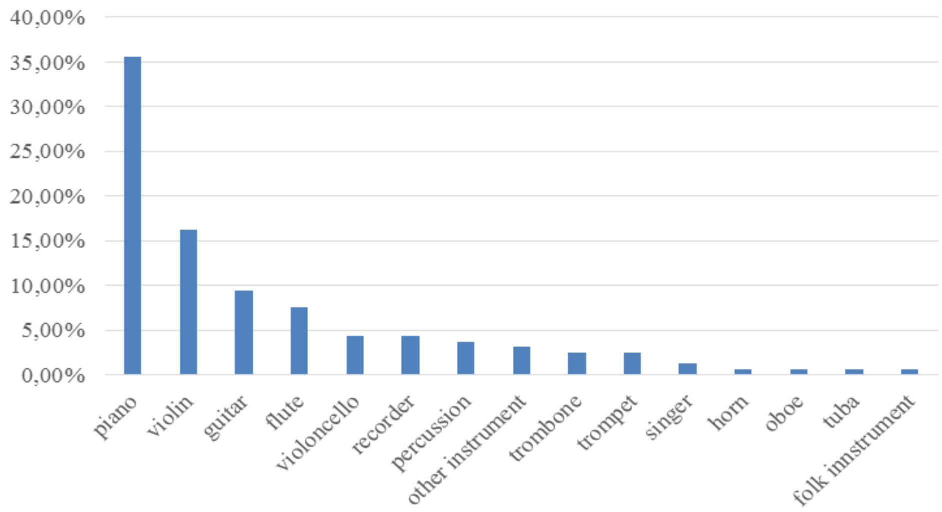
Not everyone completed the background questionnaire. Data show that 156 pupils learn solfege, one does not, and three students did not respond. Table 36 displays how long music school students have been learning solfege. It can be seen that most of them started solfege five years ago. It may be obvious that a significant correlation was found between the achievement of the music reading test and the numbers of the years spent in solfege education ($r=0.239$, $p<0.01$) although it explained only 5.7% of the variance in the music reading achievement.

Table 36 Years of studying solfege

Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**none**
%	3.7	3.1	11.2	18	25.5	18	11.2	8.8	0.6

Music school students played several kinds of instruments. Most of them (35.63%) played the piano, but there were violinists, guitar players and even folk instrumentalists in the sample as well (Figure 58).

Fig. 58 The instrumental studies of the participants (%)



The number of years spent playing a musical instrument shows a weak correlation with the students' achievement (r=0.186, p<0.05), whereas the time spent practising does not correlate with it at all.

Singing folksongs during solfege lessons proved to be the least popular activity among music school students. This phenomenon highlights the problem that there is no contemporary music (pop, rock, world music) present in the teaching material. Listening to music was the most popular activity in the higher grades. Table 37 shows students' attitudes towards the different activities of solfege lessons.

Table 37 Descriptive statistics of students' attitudes towards the different activities of solfege

		Grade 5	*Grade 6*	*Grade 7*	*Grade 8*	*F*	*p*
Music reading	M	3.38	3.50	3.64	4.22	0.444	n.s.
	SD	1.850	1.581	1.912	1.563		
Music writing	M	2.56	3.21	2.75	3.36	0.493	n.s.
	SD	1.878	1.626	1.712	1.912		
Music listening	M	4.62	4.63	5.00	5.00	1.340	n.s
	SD	1.203	1.079	0.0	0.0		
New song	M	4.00	4.27	3.93	4.31	0.201	n.s.
	SD	1.809	1.534	1.580	1.316		
Group singing	M	4.20	5.00	4.14	4.73	1.269	n.s.
	SD	1.656	0.0	1.703	0.905		
Folksong	M	1.67	2.29	1.75	2.14	0.507	n.s.
	SD	1.211	1.254	1.035	0.900		

Several studies reveal that there is a correlation between the achievement of students in schools and their motivation (Revákné, 2003). We found correlations between the students' attitude toward some activities of the solfege lesson and their achievement in rhythm reading ($r=0.286$, $p<0.01$), attitude toward singing ($r=0.237$, $p<0.01$) and between students' achievement and their attitude towards listening activities ($r=0.245$, $p<0.01$). A positive attitude towards singing correlates with music reading achievement ($r=0.305$, $p<0.01$), which accounts for 9.3% of variance in the music reading achievement. It also correlates with the achievement of the rhythm reading subtest ($r=0.204$, $p<0.05$), the melody reading subtest ($r=0.274$, $p<0.01$) and with the musical signs and concepts subtest ($r=0.177$, $p<0.026$).

7.4.2.9. Correlations of student' achievement in the music reading test and academic achievement by subject

We collected data about the students' achievement in the prior school year with the help of a background questionnaire. The students' school performance is represented by grade. No correlations were found between the students' grades in music and their music reading test achievement. Thus, the grade in music does not reflect the level of music reading skills, although music reading is one of the fundamental concepts of the Kodály concept. Most of the correlations were found with the grades of literature, grammar, biology, art, behavior, or self-discipline (Table 38). Strong positive correlations can be observed between the music reading achievements and the grades in English. This relationship may be accounted for by phoneme awareness, intonation, and listening skills that are crucial factors in language and music learning, as well. These results correspond to the literature, which claims that music has positive transfer effects on students' cognitive, metacognitive and affective skills. It is interesting to note that grades in PE also correlate with music, which has a positive effect on physical well-being.

Table 38 Correlations between students' test performance and academic achievement

Subject	*Grade 5*	*Grade 6*	*Grade 7*	*Grade 8*
Literature	0.132	0.446*	0.101	0.105
Grammar	0.028	0.476*	0.726**	0.632**
Maths	0.149	0.439*	0.289	0.616**
History	0.216	0.466*	0.654*	0.682**
English	0.151	0.569**	0.507**	0.632**
Biology	-	0.523*	0.552**	0.511**
Physics	-	0.115	0.333*	0.441*
Chemistry	-	-	0.261	0.586**
Geography	-	0.231	0.680**	0.539**
Music	-	0.069	0.067	0.241
Art	0.011	0.499*	0.321*	0.327
PE	0.044	0.338*	0.371*	0.384*
IT	-	0.344*	0.165	0.042
Behaviour	0.065	0.492*	0.494*	0.311*
Diligence	0.159	0.437*	0.723**	0.577**

Note: *=p<0.05; **=p<0.01

Music school students study different musical subjects. In grade 6, the grades in every musical subject correlate with the achievement of the music reading test, whereas grades in solfege do not show correlation with test achievement in grades 5 and 8. So it seems that the grades in solfege do not reflect the level of students' reading skills. Correlations were found between the solfege and orchestra grades of the students and their achievement in the music reading test (Table 39).

Table 39 Correlations between students' achievement and music school subjects

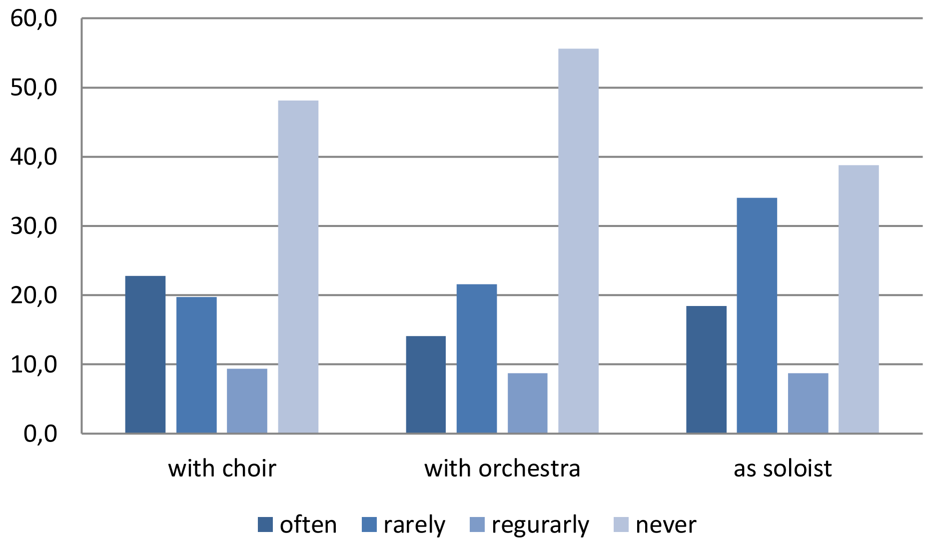
Music school subject	*Grade 5*	*Grade 6*	*Grade 7*	*Grade 8*
Solfege	0.275	0.451*	0.381*	0.192
Music history	0.146	0.724*	0.801**	0.085
Instrument	-	0.396*	0.205	0.122
Orchestra	-	0.734**		-

Note: *p<0.05; **p<0.01

7.4.2.10. Functional music literacy

27% of the students sing in a choir, while 37% of them are members of different orchestras. Students were asked how often they give a performance with an orchestra, a choir, or alone as a soloist. Most of the music school students (34.1%) perform at concerts as soloist. More than half of them have never played in an orchestra. Figure 59 shows the frequencies of different types of performances. The rhythm reading subtest correlates with performing in a choir (r=0.226, p<0.05).

Fig. 59 Means of different types of performances (%p)



It was also asked how much experience the music students have with performing, and if they liked to perform individually or in different music groups – a five-point Likert scale was used. More than 20 percent of the students agreed that they liked to perform very much, whereas approximately the half of them had never performed. The most popular performing activity among music school students is singing in a choir. Weak correlations were found between the attitudes towards two performing activities (singing in a choir and performing, as a soloist) and the music reading test achievement (Table 40).

Table 40 Correlations among attitudes towards performing and music reading achievement

	Attitude towards performance with a choir	*Attitude towards performance with an orchestra*	*Attitude towards performance as a soloist*
Music reading achievement	0.214**	0.074	0.210**

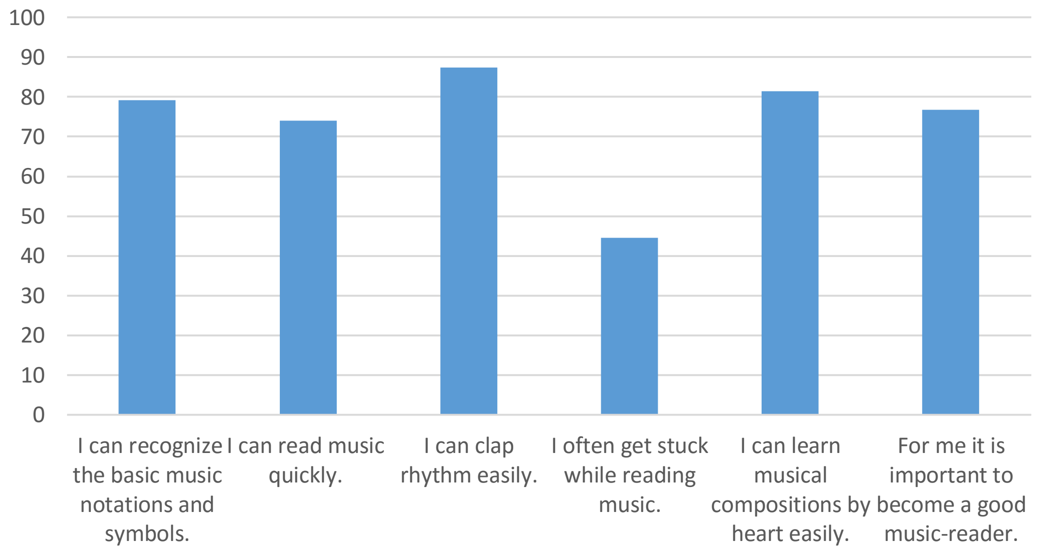
Note: **p<0.01

Weak correlations were also found between rhythm reading subtest and students' attitude towards performing in a choir (r=0.236, p<0.05), and performing with an orchestra (r=0.176, p<0.05) and performing as a soloist (r=0.233, p<0.05).

7.4.2.11. Metacognitive aspects of music reading

A five-point Likert-scale was used to elicit the responses, which helped us to identify the metacognitive music reading skills used by the music students. Approximately 80% of the music school students claimed that they could recognize basic music notations and symbols, and memorize songs quickly. More than 80% of them could clap the rhythms easily. 44% did not frequently get stuck in the musical score while playing it. Almost 80% of them would like to read music well (Figure 60). The results confirm the findings of Hollenbeck's (2008) research with secondary school students in the United States, who examined instrumentalist students' cognitive, metacognitive and affective skills with conservatory students.

Fig. 60 Means of the metacognitive aspects of music reading students (%)



Significant correlations were found between the performances of the questions in connection with some metacognitive aspects and achievement on the music reading test. Clapping the rhythms easily, and the speed of music reading show correlations with the achievement ($p<0.01$) (Table 41). Metacognitive aspects explained 30.1% of the variance in the students' music reading achievement.

Table 41 Correlations among metacognitive aspects and the music reading test achievement

	I can clap easily	*I can memorize*	*I can read music quickly*	*I know the basic notations*	*I often get stuck during music reading*	*I would like to read well*
Music reading achievement	0.275**	0.124	0.249**	0.506**	-0.164*	0.206*

Note: *p<0.05; **p<0.01

7.4.3. Summary

The reliability of the test battery proved to be good (Cronbach's alpha=0.832). The reliability of each subtest was better than in the pilot study. In the future, the reliabilities of the subtests can be improved by increasing the item numbers. The rhythm reading and the melody reading subtests were the most reliable.

There were no significant differencies between the music reading performances of the consecutive grades. However, significant difference was found in the music reading achievement between grade six and grade eight (F=4.206, p=0.007) as well as in the achievement of the subtests; aural skills and music concepts and signs. Therefore, the students' music reading skills show an improvement between these grades. The findings confirm the results of Study 3, where a developmental trend in music reading was observed between the ages of 10-14. The results also indicate the media-effect theory (Shuter-Dyson, 1999), i.e. the continuous musical inputs that surround students can develop students' aural skills.

Moderate and strong correlations were found between the achievements of the music reading test and its subtests, which presumably reflect the homogeneity of the measured skills. As expected, there is a significant correlation between the performance in the music reading test and the achievement in the map reading subtest (r=0.536, p<0.01). Consequently, students' spatial and visual skills are related to each other.

Music reading achievement does not depend on maternal education or on the socio-economic status. Gender differences are also not related to the music reading achievement. A weak correlation can be identified between boys' spatial skills and their achievement levels on the map reading test.

It was shown that there is a strong correlation between music reading achievement and most of the academic subjects; however, no correlation was shown based on the grades in music. Therefore, the grades in music do not reflect the components of music reading. It was demonstrated that the attitude towards singing moderately correlates with music reading and its components and accounts for almost 10% of the variance in the music reading achievement.

Metacognitive aspects play a linchpin role in music reading. Metacognitive components explain about 30% of variance in music reading achievement.

Our online music reading tests on the eDia platform proved to be a comprehensive assessment that is simple, practical, and easy to implement. The test can provide a more complete view of each student's ability to synthesize the skills required for music reading.

8. Study 6. Online test of music reading in mainstream schools

8.1. Pilot online assessment of music reading in mainstream schools

As described in chapter 6, the test was administered through the eDia online assessment platform in this study of music reading skills of mainstream school students. Our research questions were the following:

1. Is our online music reading test reliable in mainstream school?
2. What is the music reading achievement-level of students' performance?
3. What are the levels of the different areas of students' music reading?
4. Is music reading achievement is influenced by a positive attitude towards music lessons?

8.1.2. Methods

8.1.2.1. Participants

In our pilot study students from grades 6 to 8 from two primary schools in Szeged were involved (Table 42). Mainstream upper grader students study music once a week in 45 minute.

Table 42 Participants of Study 6

Grade	*N*	*Boys (%)*	*Girls (%)*
6	25	36.00	64.00
7	26	30.77	69.23
8	23	47.83	52.17
Total	107	38.20	61.80

8.1.2.2. Instruments

Our online music reading test version consisted of 35 multiple-choice closed questions. Each item was worth one point with a maximum possible score of 35 points. These 35 tasks were part of the music reading test designed for music school students with 55 items. The test has three subtests. The melody and rhythm reading subtests contain 14 and 13 items, respectively. The items were presented in more detail in chapter 6.

8.1.2.3. Procedures

Testing took place at the mainstream schools during IT lessons. During the testing process each student worked on a separate computer or tablet. Students had 30-35 minutes to go through all the tasks. Students read the instructions on the computer screen and received musical audio stimuli through headsets.

8.1.3. Results

The music reading test proved to be reliable: the coefficient of internal consistency for the entire sample was Cronbach's alpha=0.774. The value of Cronbach's alpha cannot be increased by deleting any of the items. When comparing the grades, we found that the reliabilities of the tests displays an increasing tendency. The test was the most reliable in grade eighth, while it was the least reliable in grade 6. The reliabilities of the music reading test and its subtests are presented in Table 43.

Table 43 The reliabilities of the online test of mainstream school students by grades (Cronbach's alpha)

Grade	*The whole test*	*Rhythm reading*	*Melody reading*	*Musical concepts and signs*
6	0.583	0.600	0.473	0.321
7	0.773	0.418	0.517	0.502
8	0.848	0.614	0.739	0.793
Total	0.774	0.565	0.572	0.627

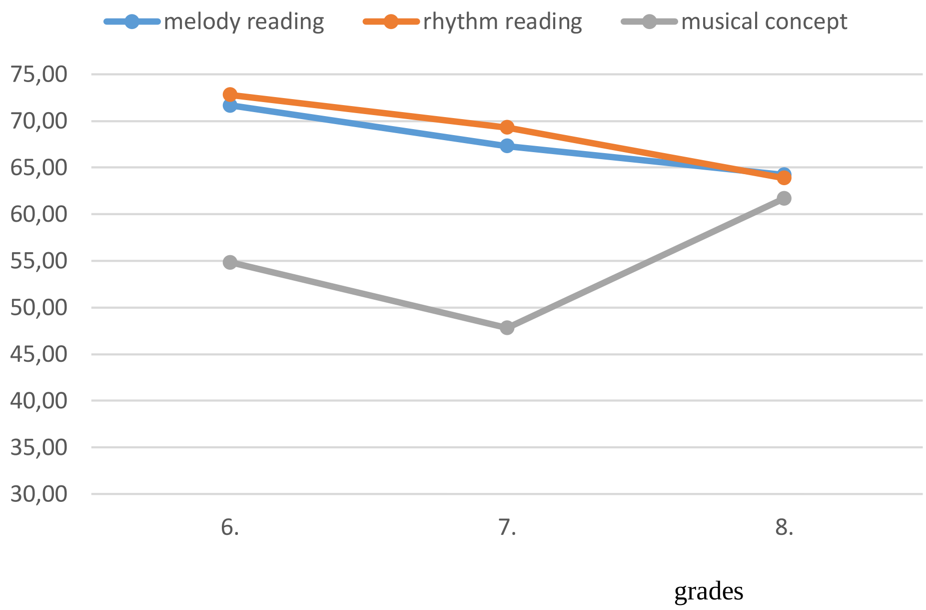
The students' mean achievement in music reading test was 64.09%. The sixth graders' achievement level was the best, whereas the eighth graders had the poorest performance. The means and standard deviations are presented in Table 44. No significant difference can be attested between the achievements of the three grades.

Table 44 Descriptive statistics of the music reading test

Grade	*Mean*	*SD*
6	23.80	4.149
7	21.92	4.436
8	21.61	6.458
Total	22.46	5.089

Mainstream school students had the best results in the rhythm reading tasks. The students' performances on the musical subtests were analyzed with the use of ANOVA. In the rhythm reading (F=1.394; p=n.s.), melody reading (F=0.966; p=n.s.), and music signs and concepts subtests (F=2.865; p=n.s.) no significant differences were attested in the different grades. Students' performances in the subtest performed in Figure 61.

Fig. 61 The development in the different types of the music reading of mainstream school students by grade (%p)



As the music reading test and its subtests strongly correlate with each other, it can be concluded that the measured skill structure is homogeneous, as it was in Study 5 (Table 45). The strongest correlations were found between students' music reading achievement and the melody reading subtest. We performed a linear regression analysis with students' music reading score as the dependent variable and the students' achievements of the subtests as independent variables. The melody reading subtest explained 22.75 % of variance in the music reading score, whereas rhythm reading subtest 18.40 % of the variance in the music reading achievement.

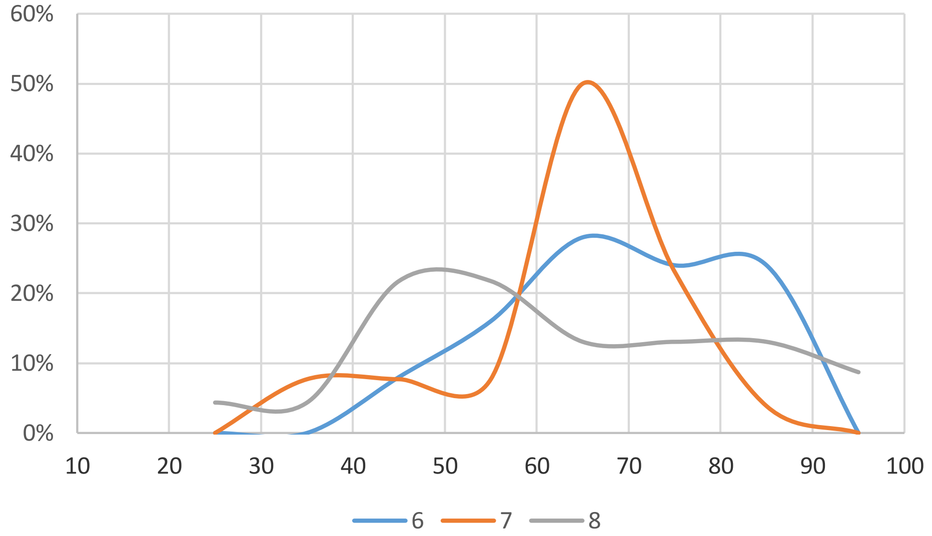
Table 45 Intercorrelations between music reading test and the subtests

	The whole test	*Rhythm*	*Melody*
Rhythm	0.843**		
Melody	0.881**	0.620**	
Concepts and signs	0.674**	0.322**	0.523**

Note: *p<0.05; **p<0.01

If we take a look at distribution, we can observe that the eighth graders' distribution curve lies more to the left, while that of the sixth and seventh graders lies more to the right of the mean. 50% of the seventh grader students achieved around 60%, while only 13% of the eighth graders had similar results. In all of the three grades, results show assymetric distribution, in the sixth and the seventh grade the curves are multimodal (Figure 62). There were only a few students whose performance was over 90%, and no one got maximum scores.

Fig. 62 The distribution of the music reading performance by grade (%p)



In the entire music reading test primary school students had the best performance in task 32, where they had to decide which musical score matches the hand signs. Almost every student gave the correct answer, which means that they successfully acquired these hand signs in the first school year, where they are introduced. A similar result can be observed with the identification of the G-clef (t14) although it is introduced only in the fifth grade. The same phenomenon can be observed with the absolute names, as more than 80% of the students identified the G-note (t15). Deviding a rhythmic exercise into 4/4 bar units (t11) proved to be the most difficult for the students, as less than 20% of them managed to solve the task. Primary school students also ran into difficulties with the definition of *Allegro* (t33), only 32% of them knew it. The pentatonic scale is very common and not only in the Hungarian folk music; however, it was difficult for the students to recognize it (t22), as less than 40% of them identified it correctly. The descriptive statistics of the items are presented in Table 46.

Table 46 Descriptive statistics of the music reading tasks (%p)

Task	*Mean (%)*	*SD (%)*
t32	98.65	11.6
t14	98.65	11.6
t26	94.59	22.8
t05	88.73	31.8
t27	87.84	32.9
t12	87.50	33.3
t07	86.30	34.6
t16	82.43	38.3
t15	82.43	38.3
t09	78.38	41.4
t06	76.71	42.6
t31	75.68	43.2
t13	75.34	43.4
t19	71.62	45.4
t23	69.44	46.4
t08	68.92	46.6
t35	67.57	47.1
t21	66.22	47.6
t10	66.20	47.6
t29	64.38	48.2
t01	60.27	49.3
t28	59.46	49.4
t03	57.53	49.8
t27	56.76	49.9
t04	56.16	50.0
t24	50.68	50.3
t30	48.65	50.3
t20	47.95	50.3
t34	44.59	50.0
t02	43.84	50.0
t18	41.89	49.7
t22	39.73	49.3
t33	32.43	47.1
t25	27.03	44.7
t11	16.67	37.5

8.1.3.1. The results of the rhythm reading subtest

The participants had the best results in task 5 and 12, where they had to identify some simpler music reading patterns, such as syncopation, quarter or semi-quarter rests. More than 70% of the primary school students were able to recognize a song by its rhythm. Dividing a rhythm exercise into simple 2/4 bars was also unproblematic for the students, while task 11 proved to be the most difficult, where they had to divide a rhythm exercise into more complex 4/4 bar units. The means of the rhythm reading tasks can be seen in Table 47. Almost in all tasks the eighth graders had the poorest achievement. In task 8 students were asked to identify a half note in a four-bar rhythm exercise only 50% eighth graders knew the correct answer. With variance analysis, a significant difference was found between the results of the sixth and eighth graders

(F=3.908, p=0.025) on task 6, where a basic music symbol, the Lombard rhythm was asked to be identified.

Table 47 The mean achievements of the rhythm reading items by grade (%p)

Task	*Grade 6*		*Grade 7*		*Grade 8*	
	M	SD	M	SD	M	SD
t01	64.00	48.99	50.00	51.08	63.64	49.24
t02	56.10	50.66	37.50	49.45	31.82	47.67
t03	61.08	50.00	66.67	48.15	45.45	50.96
t04	50.00	50.69	58.33	50.36	54.55	50.96
t05	80.06	40.82	100.00	0.00	81.82	39.48
t06	92.23	27.69	79.17	41.49	59.09	50.32
t07	88.32	33.17	83.33	38.07	81.82	39.48
t08	76.02	43.59	79.17	41.49	50.00	51.18
t09	87.00	31.19	75.00	44.23	68.18	47.67
t10	68.24	47.61	54.17	50.90	72.73	45.58
t11	16.12	37.42	8.33	28.23	22.73	42.89
t12	92.00	27.69	87.50	33.78	68.18	47.67
t13	72.03	45.83	79.17	41.49	72.73	45.58
t27	91.01	27.69	91.67	28.23	81.82	39.48

8.1.3.2. The results of the melody reading subtest

It was easy for primary school students to identify the G-clef as well as to recognize a Hungarian folk song on the basis of hand signs. Recognizing F-sharp notes (t17) posed no problem for the sixth graders; however, students tend to forget them later. Eighth and seventh graders' achievements were significantly poorer, than the sixth graders' (F=5.483, p=0.006).

Seventh graders' melodic reading was better, then the others on task 31. A significant difference was found between their results and sixth and eighth graders results (F=4.943, p=0.010). In addition, a significant difference was found between the achievements of seventh and eighth graders in task 24, where students had to recognize the tonality of a melody (F=3.224; p=0.046). Sixth graders had the best achievement (64%) on task 30, where they had to choose the correct answer from two alternatives; the first contained a rising melody ending in sol, while the second one ended in do. In this task the seventh graders achieved 42.3%, whereas the eighth graders only 39.1%. Out of the 13 reading tasks the sixth graders' performances were the best in seven tasks. They had the same results as the eighth graders in two tasks. To sum, the eighth graders were the worst in 11 melody reading tasks. The mean values of each melody reading task can be seen in Table 48.

Table 48 The mean achievements of the melody reading tasks by grade (%p)

Task	*Grade 6*		*Grade 7*		*Grade 8*	
	M	SD	M	SD	M	SD
t14	92.00	27.69	91.67	28.23	81.82	39.48
t15	88.00	33.17	83.33	38.07	72.73	45.58
t16	92.00	27.69	83.33	38.07	68.18	47.67
t17	84.00	37.42	45.83	50.90	45.45	50.96
t21	72.00	45.83	70.83	46.43	59.09	50.32
t22	44.00	50.66	33.33	48.15	45.45	50.96
t23	76.00	43.59	62.50	49.45	59.09	50.32
t24	56.00	50.66	29.17	46.43	63.64	49.24
t28	48.00	50.99	70.83	46.43	63.64	49.24
t29	56.00	50.66	75.00	44.23	40.91	50.12
t30	64.00	48.99	37.50	49.45	40.91	50.32
t31	60.00	50.00	95.83	20.41	68.18	47.67
t32	100.00	0.00	95.83	20.41	100.00	0.00

8.1.3.3. The results of the musical concepts and signs subtest

Students learn about the musical instruments from the first years in the primary school. They get acquainted with string instruments, such as violin and violoncello or the doublebass, in the second grade with the help of different musical pieces. The most popular one is The Swain, from the Carnival of Animals composed by Saint-Saens. The timbre of the cello is unique. It can be easily distinguished from the higher tone of the violin, or the lower doublebass. For the students recognizing a wind orchestra was extremely problematic. Sixth graders' achievement was the best in this task, with a significant difference between the sixth and seventh graders achievements ($t=1.704$, $p<0.001$). The mean values of each task can be seen in Table 49.

Table 49 The mean achievements of the musical concepts and signs subtest items by grade (%p)

Task	*Grade 6*		*Grade 7*		*Grade 8*	
	M	SD	M	SD	M	SD
t18	56.00	50.66	12.50	33.78	54.55	50.96
t19	64.00	48.99	83.33	38.07	63.64	49.24
t20	44.00	50.66	33.33	48.15	63.64	49.24
t25	36.00	48.99	16.67	38.07	31.82	47.67
t26	96.00	20.00	91.67	28.23	95.45	21.32
t33	12.00	33.17	29.17	46.43	63.64	49.24
t35	76.00	43.59	58.33	50.36	68.18	47.67

8.1.3.4. Students' attitude towards music lessons

Examining the background variables we found that pupils are less and less interested in each part of a music lesson from grade 6 to 8 (Table 50). In our sample eighth graders had the most negative attitude towards learning the musical concepts. The attitude towards singing gets worse from grade 6. With the achievement of the music reading test only the variable of the positive attitude towards singing correlates ($r=0.302$, $p<0.05$).

Table 50 The descriptive statistics of the attitude towards the different part of music lesson

Parts of music lessons	*Grades*						*Total*	
	6		7		8			
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Music reading	2.54	0.977	2.87	1.140	2.00	0.816	2.50	1.041
Music writing	2.52	0.790	2.83	1.114	2.05	0.848	2.49	0.970
Singing	3.63	1.056	3.52	0.947	3.00	1.453	3.41	1.163
Music listening	4.38	0.576	4.13	0.968	4.20	0.768	4.24	0.780
Music concepts	2.50	0.913	2.52	1.123	1.94	0.899	2.35	1.010
Folk music	2.88	0.881	2.87	1.014	2.06	0.827	2.55	0.958
New song	3.48	1.078	3.17	1.029	3.00	1.374	3.22	1.156
Instruments	3.48	0.898	3.22	1.278	3.00	1.118	3.25	1.122
Composers	2.82	1.006	2.86	1.207	2.39	1.145	2.71	1.120

8.1.4. Conlusions

The online music reading test in mainstream schools was reliable. The reliabilities of the subtests are also adequate. As far as music reading achievement is concerned, no significant differences were identified between the grades. Sixth graders had the highest achievement in the music reading test, whereas the eighth graders had the poorest performance.

It can be concluded that one music lesson a week is not enough, as it yields only the stagnation of the level of the music reading skills. As in the previous studies, the test and its subtests strongly correlate with each other, so the measured skill structure is homogeneous.

Music students performed best on the task with hand sign reading. Hand signs, related to relative solmisation, are introduced in the first grade, which means that students have time to acquire them. On the other hand, the pentatonic scale which can also be regarded as a musical universal seemed to be difficult for the students to read.

The results of the rhythm reading subtest indicate that students cannot recognize meters properly. Even simple metres posed problems for the students. The results support the findings of Study 2 when four graders' rhythmic reading was analysed and it was found that none of them is able to keep the steady beat.

After analyzing the background variables, I came to the conclusion that students show less and less interest in music lesson from grade 6 to 8. The results confirm Csapó's claim (2000, cited in Dohány, 2009) that students' attitude and motivation towards the different school subjects significantly decrease with school years. We also found that positive attitude towards singing correlates with the music reading test achievement. Phillips and Aitchison (1998) suggest that students who do not like to sing, especially boys in the upper grade levels, may respond negatively to all parts of music instruction. So early intervention strategies that make students feel that they are confident and successful singers are necessary for them in the intermediate grades.

8.2. Study 7. Large-scale assessment of music reading skills in mainstream schools

For describing the results of the large-scale measurements firstly we present the results of testing music reading skills in mainstream education. The aim of our research is to investigate the results of the music reading test which can help us to get an overall picture of 10-14 year-old students' music reading skills. In the previous chapter, we have already summarized the reliabilities of our pilot studies, that considered being acceptable for the following measurements. The following questions were phrased in the large scale measurement:

1. Is our online music reading test reliable in mainstream school?
2. What is the music reading achievement-level of students' performance?
3. What are the levels of the different areas of students' music reading?
4. Do visual-spatial skills correlate with music reading skills?

8.2.2. Methods

8.2.2.1. Participants

The cross-sectional large-scale measurement was conducted in eight primary schools across Hungary in January 2016. The sample consists of 10-14 year old students (N=651) from eighth mainstream schools. All the students studied music from their first grade on, receiving one lesson per week. Table 51 displays the locations of the participating schools. The sample is non representative, but reflects the variegation of the population.

Table 51 The number of the students from the participating mainstream schools in the different towns

Municipality	*Number*
Szeged	202
Kecskemét	158
Budapest	115
Csongrád	103
Törökszentmiklós	73
Total	651

8.2.2.2. Instruments

The assessment battery included three subtests, namely rhythm, melodic and musical signs and concepts subtests. Each of the measures of these constructs was described in chapter 6. The test contained 35 items. Each item was worth one point with a maximum possible score of 35 points. These 35 tasks were part of the music reading test designed for music school students with 55 items. The melody and rhythm reading subtests contain 14 and 13 items, respectively.

Map reading items were not part of the music reading test, but we were interested whether mainstream school students' spatial skills correlated with their music reading skills. The map reading test was also presented in chapter 6. The test measured students' orientational ability with three closed items.

8.2.2.3. Procedures

The online testing process was similar to the ones in the previous. The tasks can be done in any order, and corrections can be made any time before the end of the test. Students are not allowed to be given any information about the tasks prior to testing and no outside aids can be used. Pupils have 30-35 minutes to finish their work; it was allowed those students who need more time to complete it, as well. After the test students were asked to fill in a background questionnaire so that the relationship between music reading skills and other background variables can be explored. It takes 10-15 minutes to fill in the questionnaire, which can be found right after the test. Data processing was performed with the use of the SPSS 21 software.

8.2.3. Results

The reliability of the online music reading test was 0.839. The reliabilities are good in each grade from 5 to 8. The reliability of the test was the highest (Cronbach's alpha=0.865) in the seventh grade (Table 52).

Table 52 The reliabilities of the music reading test by grade (Cronbach's alpha)

Grade	*N*	*Cronbach-alfa*
5	184	0.807
6	139	0.820
7	168	0.865
8	159	0.855
Total	650	0.839

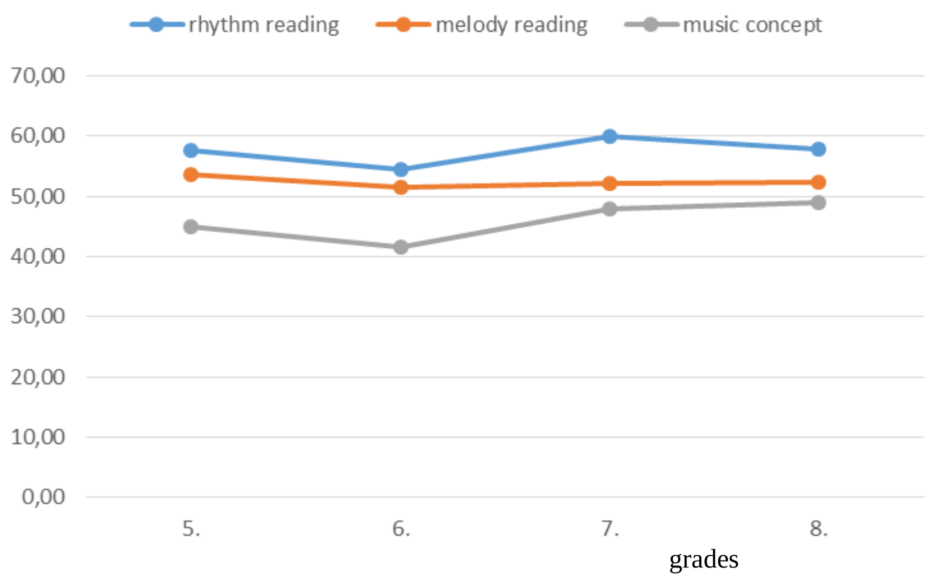
The reliabilities of the subtests are presented in Table 53. Mainly because of the larger sample, the reliability of each subtest proved to be better than in the pilot study. The rhythm reading subtest had the highest reliability in the seventh grade (Cronbach's alpha=0.747). Map reading tasks were not part of the music reading test, but we were interested whether students' spatial skills correlated with music skills. It is assumed that the poor reliability of this subtest is due to the lower item number, i.e. three. The reliability of the map reading test is Cronbach's alpha=0.507. This test is the most reliable in grade eighth (Cronbach's alpha=0.578).

Table 53 The reliabilities of the online test on the large sample of mainstream school students by grade (Cronbach's alpha)

Grade	*The whole test*	*Rhythm reading*	*Melody reading*	*Musical concepts and signs*
5	0.807	0.714	0.699	0.471
6	0.820	0.730	0.683	0.289
7	0.865	0.747	0.743	0.563
8	0.855	0.727	0.738	0.578
Total	0.839	0.729	0.717	0.507

Primary school students' mean performance on the music reading test was 54.84%. According to the results of ANOVA, there were no significant differences between the four grades. Sixth graders had a slightly lower achievement than the average (52.33%) although it was not significant ($F=1.110$; $p=0.344$). The students' achievement in music reading by grade is presented in Figure 63.

Fig. 63 The achievements of the subtests of mainstream school students by grade (%p)



The level of difficulty of the online tasks can be examined by the means and the corresponding standard deviation values. The minimum and maximum values are redundant, for each 0% and 100% are listed. Students' average of achievement on the music reading test is 55.23%; the corresponding standard deviation is 24.62. Similar averages are found in most of the rhythm reading tasks. The recognition of the musical key had the highest mean (96%). The knowledge of sol-fa hand signs had a high mean (81%) as well. As it was already observed in the pilot studies, students found it easier to solve the rhythm reading tasks together with a soundtrack (87%). Tasks in connection with timbre (29%) and dynamic reading got the lowest average (34%). Table 54 summarizes the rate of achievement of the music reading tasks, so the level difficulty is ranked hierarchically. An item-analysis was also carried out by means of examining corrected item-total correlations. The last column presents item-deleted reliability, the value that Cronbach's alpha would be if that particular item was deleted from the scale.

Table 54 The descriptive statistics of the music reading tasks

Task	*Mean (%p)*	*SD (%)*	*Item-total correlation*	*Item-deleted reliability*
t14	95.85	20.0	0.260	0.839
t27	87.38	33.2	0.227	0.838
t26	81.38	39.0	0.234	0.838
t32	80.77	39.4	0.179	0.839.
t19	74.62	43.6	0.212	0.838
t12	74.27	43.7	0.268	0.837
t28	69.69	46.0	0.276	0.837
t31	68.31	46.6	0.276	0.837
t05	66,62	47.2	0.418	0.833
t13	66.15	47.4	0.376	0.834
t23	62.31	48.5	0.472	0.831
t34	58.15	49.4	0.186	0.840
t29	57.54	49.5	0.431	0832
t15	56.92	49.6	0.436	0.832
t07	56.00	49.7	0.180	0.840
t06	55.08	49.8	0.286	0.837
t10	54.00	49.9	0.406	0.833
t01	52,92	50.0	0.388	0.833
t03	52.00	50.0	0.383	0.834
t08	51.54	50.0	0.393	0.833
t04	48.31	50.0	0.428	0.832
t06	48.00	50.0	0.286	0.837
t11	47.54	50.0	0.459	0.831
t09	43.23	49.6	0.513	0.829
t02	42.77	49.5	0.376	0.834
t21	42.46	49.5	0.576	0.828
t22	40.31	49.1	0.178	0.843
t24	40.31	49.1	0.345	0.835
t30	40.15	49.1	0.268	0.837
t33	38.77	48.8	0.263	0.837
t35	34.00	47.4	0.480	0.831
t25	32.31	46.8	0.197	0.840
t17	31.85	46.6	0.608	0.827
t18	31.54	46.5	0.403	0.833
t20	29.38	45.6	0.189	0.841

As the music reading test and its subtests strongly correlate with each other, it can be concluded that the measured skill structure is homogeneous, as it was in the previous studies (Table 55). The correlations are even stronger than between the results of the whole test and its subtest in the pilot test. A very strong correlation was identified between students' music reading achievement and the melody reading subtest. A moderate correlation was found between the results of the map reading test and the students' achievement on the music reading test. The results show a moderate correlation between the achievements of the map reading test and the subtests. We performed a regression analysis with students' music reading score as the dependent variable and the students' achievements of the subtests as independent variables. The melody reading subtest explained 22.56 % of variance in the music reading score, whereas rhythm reading subtest 21.16 % of the variance in the music reading score.

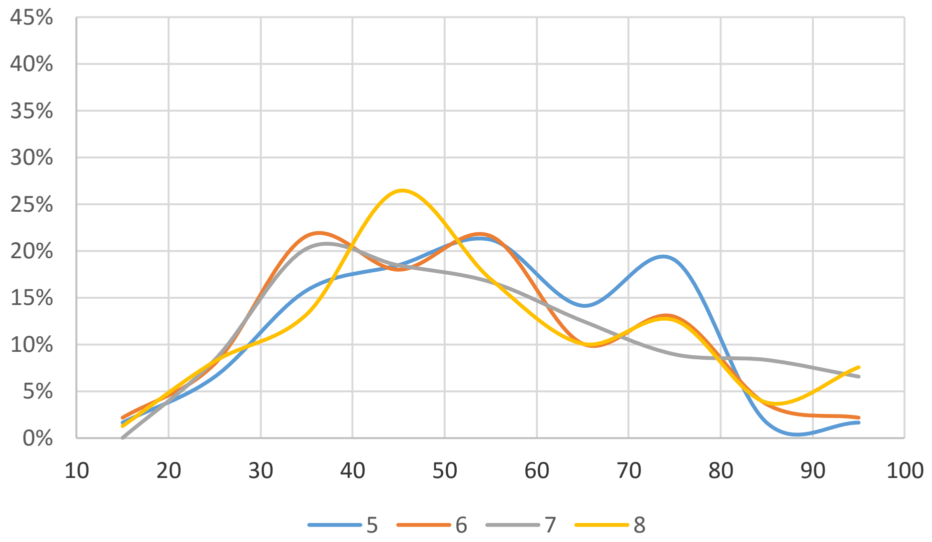
Table 55 Intercorrelations between music reading test, rhythm reading, melody reading, concepts and signs subtests and map reading test

	The whole test	*Rhythm*	*Melody*	*Concepts and signs*
Melody	0.880**	0.607**		
Concepts and signs	0.674**	0.458**	0.322**	
Map reading	0.419**	0.389**	0.389**	0.250**

Note: *p<0.05; **p<0.01

No students got top scores in the music reading test. The distribution curves of each grade lies to the left of the mean (Figure 64). Sixth, seventh and eighth graders had multimodal curves. Normal distribution is observed in the seventh grade, where they achieved around 50%. No one had a lower achievement than 15%. The fifth graders had the best results, as more than 20% showed good performance, over 70%, while nearly half of the seventh and eighth graders had poorer results than 45%. From the sixth grade the rising rate of lower achievers can be observed. 90% of achievement remains under 10% in every grade. No one achieved 100% at all.

Fig. 64 The distribution of the music reading performance by grade (%p)



8.2.3.1. The results of the rhythm reading subtest

The internal structure of the different types of rhythm reading tasks, and the relationship between the tasks were explored as well. Table 56 displays an overview of the results of the rhythm reading subtest related to metrum. The task with simple 3/4 time signature was the easiest for the students, as 74% of them were able to solve it. Interestingly the recognition of 2/4 time signature (t02 and t04) proved to be the most difficult tasks for the students.

Table 56 Descriptive statistics of the rhythm reading tasks on metrum (%p)

Rhythm reading tasks	*Task*	*Mean*	*SD*
Metrum &bars			
	t12	74.27	43.7
	t13	66.13	47.4
	t10	54.0	49.9
	t01	52.92	50.0
	t03	52.0	50.0
	t04	48.31	50.0
	t11	48.0	50.0
	t02	42.77	49.6

The task on syncopation (t05) was solved by 67% of the students. Students got means close to the average of the rhythm reading test, i.e. recognizing a Lombard rhythm (t6) (55%) or a half note (t8) (52%). The results of the recognition of a semi-quarter pause (t9) were below the average of the test (Table 57).

Table 57 Descriptive statistics of the rhythm reading tasks on rhythmic patterns (%p)

Rhythm reading tasks	*Task*	*Mean*	*SD*
Rhytmic patterns			
	t27	87.38	33.2
	t05	66.62	47.2
	t07	56.0	49.7
	t06	55.08	49.8
	t08	51.54	50.0
	t09	43.23	49.6
	t02	42.77	49.6

66% of them recognized a song by its rhythm (t13). Two internationally well-known and popular songs, i.e. *Silent Night* and *Twinkle, twinkle, Little Star,* were chosen for this task. In the tasks where rhythmic elements and meters had to be identified, students performed below the average on the rhythm reading subtest. Students' achievement by grade can be observed in Table 58.

Table 58 Descriptive statistics of the different rhythm reading tasks by grade

Grade	*Rhythm reading*		*Rhythmic pattern*		*Bars*		*Time signature*		*Song's rhythm*	
	M	SD	M	SD	M	SD	M	SD	M	SD
5	55.25	23.65	54.45	26.89	62.22	33.05	48.23	34.37	73.36	44.32
6	51.79	24.44	51.36	27.72	66.54	34.78	42.62	35.41	61.15	48.91
7	57.83	25.53	57.14	29.46	67.36	36.37	52.82	35.71	63.09	57.83
8	55.45	24.77	54.46	27.77	61.00	37.58	51.41	36.48	48.39	25.53
Total	55.23	24.62	54.49	28.01	64.17	35.45	49.00	35.58	65.40	55.45

We performed regression analysis with students' rhythm reading subtest achievement as the dependent variable and the students' achievements on each item of the rhythm reading subtests as independent variables. The product of r and β shows the explained variance values of the tasks, ranging from 5.46 to 10.45%. This can be considered a well-balanced result (Table 59). According to the results obtained from the analysis of variance, task 4 (recognizing a 2/4 metre) and task 9 (semiquater rhythmic pattern) contribute most to the explained variance. They are responsible for over a 10% of the explained variance, while the poorest contribution is a value of 5%.

Table 59 Regression analysis of the rhythm reading tasks

Independent variable: tasks of the rhythm reading subtest	*r*	*β*	*r*β (%)*
t01	0.568	0.169	9.60
t02	0.575	0.168	9.64
t03	0.588	0.169	9.95
t04	0.325	0.169	5.45
t05	0.507	0.160	8.09
t06	0.430	0.169	7.24
t07	0.325	0.168	5.46
t08	0.488	0.169	8.27
t09	0.612	0.168	10.27
t10	0.524	0.169	8.84
t11	0.317	0.160	5.08
t12	0.356	0.148	5.71
t13	0.398	0.160	6.38
Total			100

The performance patterns of mainstream students were similar than those on the pilot test. They had the poorest achievement on tasks 2 and 9, where they had to identify a semi-quarter rest and time signature. Around 70% of the primary school students were able to divide a rhythm exercise into simple 3/4 bars. The best result in this task was achieved by the sixth graders

(76.26%), while eighth graders achieved only 71.07%. 66.15% of the students recognized a song from its rhythm. The fifth graders had the best results with 73.37%, while sixth graders had a lower achievement, i.e. 61.15%. Sixth graders' results were significantly lower, than the seventh and the eighth graders on task 1, where students are asked to choose the correct metrum ($F=3.786$, $p=0.010$).

Task 8, where students had to identify a half note, was less problematic for the fifth graders. 73.91% of them solved the task, whereas only 60% of the eighth graders managed to do so. There were no tasks where the eighth graders had the best results. The mean values of each rhythm reading task can be seen in Table 60.

Table 60 The mean achievements of the rhythm reading items by grade (%p)

Task	*Grade 5*		*Grade 6*		*Grade 7*		*Grade 8*	
	M	SD	M	SD	M	SD	M	SD
t01	54.89	49.90	41.01	49.36	59.52	49.23	54.09	49.99
t02	39.13	48.94	37.41	48.56	48.21	50.12	45.91	49.99
t03	52.72	50.06	47.48	50.12	54.76	49.92	52.20	50.11
t04	46.20	49.99	44.60	49.89	48.81	50.14	53.46	50.04
t05	73.91	44.03	66.91	47.23	64.29	48.06	60.76	48.98
t06	48.91	50.12	51.80	50.15	62.50	48.56	57.23	49.63
t07	48.37	50.11	55.40	49.89	61.90	48.71	59.12	49.32
t08	51.63	50.11	46.04	50.02	51.79	50.12	55.97	49.80
t09	49.46	50.13	36.69	48.37	45.24	49.92	39.62	49.07
t10	48.91	50.12	56.83	49.71	60.12	49.11	51.27	50.14
t11	15.76	36.54	18.71	39.14	9.52	29.44	14.47	35.29
t12	75.54	43.10	76.26	42.70	74.40	43.77	71.07	45.49
t13	73.37	44.32	61.15	48.92	63.10	48.40	65.41	47.72
t27	87.50	33.16	87.77	32.88	86.90	33.84	87.42	33.27

8.2.3.2. The results of the melody reading subtest

The mean of students' performance in the music reading subtest is 52.78, with a standard deviation of 25.40. Students' achievement was poorer on melody reading than on the rhythm reading tasks. The task with G-clef was the easiest, with 96% of the students solving it. 62% of students recognized songs from their notations. The results of the task with note names were 57%, whereas recognizing a pentatonic scale and the perfect fifth was below the average of the subtest. In Table 61 the descriptive statistics of all the melody reading items are demonstrated.

Table 61 Descriptive statistics of the melody reading tasks (%p)

Task	*M*	*SD*
t14	95.85	20.0
t32	80.77	39.4
t31	68.31	46.6
t23	62.31	48.5
t34	58.15	49.4
t29	57.54	49.5
t15	56.92	49.6
t16	47.54	50.0
t21	42.46	49.5
t22	40.31	49.1
t24	40.31	49.1
t30	40.15	49.1
t17	31.85	46.6

According to the requirements of Hungarian music curricula the knowledge of different notation systems is considered to be well established in the first four years of primary school music education. Students' achievement on the melody reading subtest was much higher than the entire test results (74.53%), with a standard deviation of 33.21. This includes the knowledge of letter notation (68%) and hand signs (80.77%). Reading dynamic notation was difficult, with only 34% of the students choosing the correct answer. Pupils were able to discriminate between different instrumental and singing groups. Even though students recognized a wind instrument (75%), it was difficult for them to identify the string instruments (32%).

We performed a regression analysis with students' melody reading subtest achievement as the dependent variable and the students' achievements of the subtests' items, as independent variables. The regression analysis of the tasks is illustrated in Table 62. The range is wider now than in the case of rhythm reading. According to the results obtained from the analysis of variance, task 21, the recocnition of the Perfect Fith interval, the knowledge of the absolute note names (G, A and F-sharp) (t15, t16 and t17) contribute most to the explained variance. They are responsible for over a 10% of the explained variance. Task 14 had the poorest contribution; therefore, it would not change the outcome of the music reading test significantly if we deleted it.

Table 62 Regression analysis of the melody reading tasks

Independent variable	*r*	*β*	*r*β (%)*
t14	0.183	0.087	1.60
t15	0.593	0.217	12.86
t16	0.654	0.219	14.30
t17	0.703	0.204	14.34
t21	0.364	0.216	14.88
t22	0.304	0.215	6.52
t23	0.641	0.212	7.73
t24	0.434	0.215	9.32
t29	0.205	0.316	6.50
t30	0.188	0.322	6.06
t34	0.266	0.220	5.86
Total			100

Primary school students from the different grades had similar results in the melody reading subtest. The eighth graders had the best achievement only in the first task, where it was easy for them to identify the G-clef, about 96% of the students gave correct responses. Just like in the pilot test, recognizing a Hungarian folk song from hand signs was not problematic either. 86% of the sixth graders accomplished the task, while less then 80% of the eighth graders were able to do so. Recognizing F-sharp notes (t17) was difficult in each grade, with the eighth graders having the poorest achievement (30.19%). Again, the fifth graders were the best, with 33.7%. No significant difference was found between the results. The mean values of each melody reading task by grade can be seen in Table 63.

Table 63 Mean achievements of the melody reading items by grade (%p)

Task	*Grade 5*		*Grade 6*		*Grade 7*		*Grade 8*	
	M	SD	M	SD	M	SD	M	SD
t14	94.57	22.73	95.68	20.40	96.43	18.61	96.86	17.51
t15	61.41	48.81	56.12	49.80	50.60	50.15	59.12	49.32
t16	42.93	49.63	44.60	49.89	51.19	50.14	51.57	50.13
t17	33.70	47.40	31.65	46.68	31.55	46.61	30.19	46.05
t21	40.48	49.23	40.16	49.23	48.37	50.14	43.88	49.80
t22	48.91	50.12	40.29	49.23	35.71	48.06	35.22	47.92
t23	69.02	46.37	57.55	49.60	63.25	48.36	58.23	49.48
t24	37.50	48.54	37.41	48.56	45.51	49.95	40.76	49.30
t25	32.07	46.80	40.29	49.23	26.79	44.42	31.45	46.58
t26	86.31	34.48	79.84	40.27	75.50	43.15	80.14	40.03
t27	87.50	33.16	87.77	32.88	86.90	33.84	87.42	33.27
t29	61.41	48.81	58.99	49.36	51.79	50.12	57.86	49.53
t30	40.98	49.32	42.22	49.58	36.31	48.23	42.14	49.53
t31	70.11	45.90	61.31	48.88	72.62	44.72	67.72	46.90
t32	76.63	42.43	85.51	35.33	82.74	37.90	79.87	40.22
t34	61.41	48.81	59.42	49.28	54.17	49.98	57.86	49.53

Only around the 58% of the students succeeded in accomplishing the task where the style of folk song had to be recognized. Table 64 demonstrates the relative frequencies (in percentages) of each melody reading task types. The performances from the fifth grade can be seen on Table 64. No significant differences were attested between the grades.

Table 64 Descriptive statistics of the different parts of music reading by grade (%p)

Grade	*Melody reading*		*Dynamic reading*		*Notation systems*		*Impro-visation*		*Style recognition*	
	M	SD	M	SD	M	SD	M	SD	M	SD
5	54.52	25.30	34.78	47.75	73.36	33.01	40.76	49.27	61.41	48.81
6	51.31	24.49	32.30	41.77	73.02	32.56	41.72	49.48	58.99	49.36
7	52.38	25.91	39.28	48.98	77.67	32.72	36.30	48.23	54.16	49.97
8	52.48	25.85	37.73	48.62	73.89	34.60	42.13	49.53	57.86	49.53
Total	52.78	25.40	34.00	47.40	74.53	33.21	40.15	49.36	58.15	49.36

8.2.3.3. The results of the musical concepts and signs subtest

In the subtest students were asked about the basic musical concepts and signs. The trumpet is a well-known instrument, which is supported by the fact that 80.36% of the seventh graders identified it correctly. Even fifth graders had a good result (67.93%) in this task. The seventh graders had the best results in task 33 as well, where they had to define what the term *Allegro* means. A significant difference was found between their achievement and the sixth graders' result ($t=3.141$, $p<0.001$). Students achieved 34.1% on task 35, where they had to identify the *decrescendo sign*, with only 37.97% of the eighth graders knowing the right answer. The mean values of each task of the music concepts and signs can be seen in Table 65.

Table 65 The mean achievements of the musical concepts and signs items by grade (%p)

Task	*Grade 5*		*Grade 6*		*Grade 7*		*Grade 8*	
	M	SD	M	SD	M	SD	M	SD
t18	34.24	47.58	25.90	43.97	32.74	47.07	32.08	46.82
t19	67.93	46.80	72.66	44.73	80.36	39.85	78.48	41.23
t20	22.28	41.73	17.99	38.55	32.14	46.84	44.65	49.87
t25	32.07	46.80	40.29	49.23	26.79	44.42	31.45	46.58
t26	86.31	34.48	79.84	40.27	75.50	43.15	80.14	40.03
t33	36.96	48.40	30.43	46.18	47.62	50.09	38.99	48.93
t35	34.78	47.76	22.46	41.89	39.29	48.98	37.97	48.69

8.2.3.4. The results of the map reading test

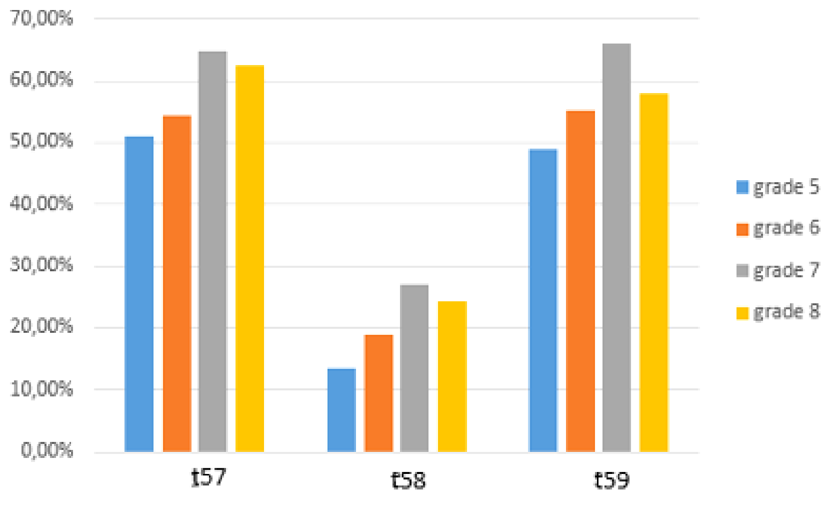
In order to investigate the relationship between music reading skills and spatial skills, three map reading tasks were used. Students' performance on these tasks was close to the achievement of the music reading tasks (Table 66). Students had the highest achievement on task 59, where they were supposed to find a school on a simple map.

Table 66 Descriptive statistics of the map reading tasks (%p)

Task	*M*	*SD*
t59	58	49.4
t57	56	49.6
t58	21	40.5

Just like in the music reading test, eighth graders' achievements were the poorest in the map reading test as opposed to the seventh graders, who had the best results in all the three tasks. The mean values of each map reading task can be seen in Figure 65. No significant differences were between the grades.

Fig. 65 The mean achievements of the map reading items by grade (%p)



As expected, a highly significant correlation was found between the achievements of the music reading test and the achievement of the map reading test ($r=0.407$, $p<0.01$).

8.2.3.5. Factors that influence music reading

Test achievement could be affected by several background variables. We found that neither the mother highest education, nor students' socio-economic status influences students' music reading achievement (Table 67).

Table 67 The correlation between the achievement of the music reading test and the mother's highest level of education by grade

	Elementary		*Secondary*		*Tertiary education*			
	M	SD	M	SD	M	SD	F	p
Grade 5	46.47	23.658	54.93	15.991	56.757	18.109	0.832	n.s.
Grade 6	49.27	15.069	52.941	17.384	53.775	17.838	0.134	n.s.
Grade 7	58.21	24.055	56.95	19.953	52.84	17.576	0.691	n.s.
Grade 8	52.21	22.889	53.41	18.483	57.41	19.632	0.753	n.s.

Our expectations were also confirmed that the girls' results were significantly better than that of boys in each grade (Table 68). The girls in the seventh grade had the best results (59.6%). In every grade for about 6%p difference can be found between the results of the boys and the girls.

Table 68 The means and standard deviations (%) by gender and grade

Grade	*Boys*		*Girls*		*Levene*		*T-test*	
	M	SD	M	SD	F	p	t	p
5	51.9	17.8	57.6	16.4	0.37	0.54	-2.25	0.02
6	49.0	18.6	55.1	16.3	1.57	0.21	-2.04	0.04
7	52.7	18.8	59.6	21.0	3.35	0.06	-2.23	0.02
8	52.1	19.7	58.5	19.1	0.04	0.85	-2.05	0.04
Total	51.6	18.7	57.7	18.1	0.004	0.94	-4.20	0.00

Significant differences are found between genders in all cases ($p<0.001$)

8.2.3.6. The differences between the two school types

If we compare the achievements of the two different types of school, music school students' achievement was higher, 76.69% (SD=16.47), while that of mainstream school students was 55.23%, with the corresponding standard deviation of 24.62. The achievements are not surprising at all, for there is more emphasis on teaching music reading in music schools.

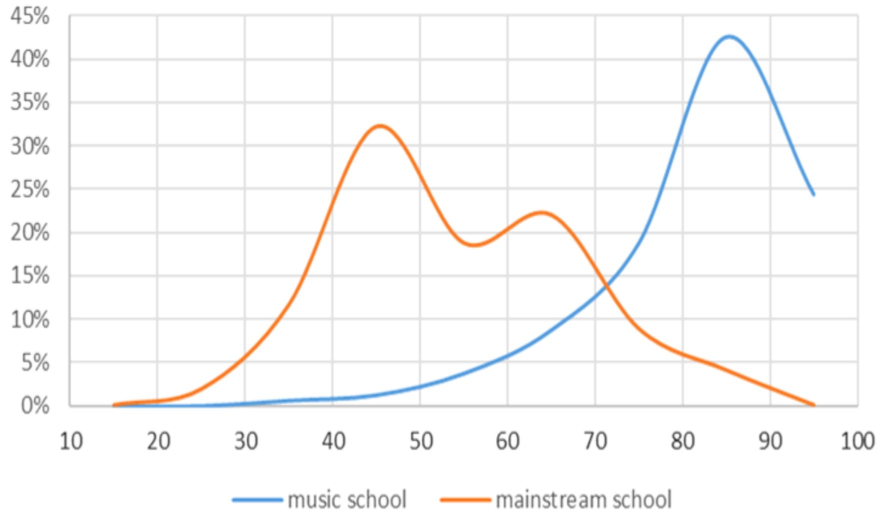
35 items were part of both version of the music reading tests in the two school types. The core test was filled by 811 10-14 year-old students. The results by grade are presented in Table 69.

Table 69 Descriptive statistics of the core music reading test by grade (%p)

Grade	*M*	*SD*
5	40.45	32.56
6	45.07	30.44
7	54.95	33.39
8	52.59	34.0
Total	48.32	33.15

The distribution curves of the core test of the music reading tests in the two school types were examined. It is obvious that these tasks were easier for the music school students, and more difficult for the primary school students. 67% of the music school students performed better than 85%, while only 4% of the primary school students managed to do so. The music school students' distribution curve is located more to the right of the mean, so the music reading test with only these 35 items proved to be easy for them, and cannot differentiate properly (Figure 66). Mainstream school multimodal distribution falls to the left that means the test was difficult for them. 63% of them had poorer achievement than 50%.

Fig. 66 The distribution of music reading performance of the two school types (%p)



We compared the results of the music reading core test between the different types of schools. We found significant differences in each grade (Table 70).

Table 70 Differences in the acievement of music reading test in the two types of schools by grade

Grade	*Mainstream school*		*Music school*		*T-test*	
	M	SD	M	SD	t	p
5	55.19	17.16	79.65	13.83	13.837	<0.001
6	52.33	17.59	78.25	11.81	11.889	<0.001
7	55.89	20.09	81.81	11.37	11.378	<0.001
8	55.49	19.57	85.08	10.74	10.741	<0.001
Total	54.84	18.65	81.21	12.14	12.147	<0.001

When we compared the results of the map reading test, significant differences were found each grade (Table 71).

Table 71 Differences in the acievement of map reading test in the two types of schools by grade

Grade	*Mainstream school*		*Music school*		*T-test*	
	M	SD	M	SD	t	p
5	37.86	31.70	40.45	32.56	2.708	0.007
6	42.75	29.86	45.67	30.44	2.339	0.020
7	52.49	34.01	54.95	33.39	2.237	0.026
8	47.98	34.86	52.59	34.04	3.821	<0.001
Total	45.14	33.147	48.32	33.15	5.576	<0.001

Significant differences were found in the achievement of each common task of every subtest. For example, in rhythm reading, almost 80% of the music school students solved the task with 4/4 meter, while only 14.46% of the mainstream school students knew the correct answer. The tendencies are similar in the melody reading tasks between the two school types. The biggest difference is found in the tasks where the knowledge of the musical notes, and the perfect fifth were tested (Appendix G).

Similar to the achievement of the music reading test, music school students proved to be significantly better on each common map reading items (Table 72).

Table 72 Differences in the acievement of music reading test in the two types of schools

Common map reading tasks	*Music school* M (SD)	*Mainstream school* M (SD)	*Levene test* *F*	*p*	*T test* *t*	*p*
t57	82.50 (38.11)	58.02 (49.39)	29.378	<0.001	6.829	<0.001
t58	32.50 (46.98)	20.74 (40.57)	30.649	<0.001	2.909	0.004
t59	68.55 (46.57)	56.81 (86.87)	47.456	<0.001	2.811	0.005

8.2.4. Summary

After being piloted the online test in mainstream schools, a large-scale assessment was conducted to test 10-14 year-old students' music reading skills in Hungary. Besides the music reading skills, students' spatial skills were tested with the help of an online map reading test. The online music reading test proved to be an appropriate tool for measuring music reading skills in general school settings. It was also suitable for testing larger groups simultaneously. The reliabilitiy of the online test was 0.839, with the highest reliability in the seventh grade (0.865). Students' achievements on the tests confirmed that the tests suited the students' music reading skill level. Both the pilot and the large scale assessments show that the music reading test and its subtests correlate, so the measured skill strucure is homogeneous.

No significant differences were found between the achievements in the four grades. So in the upper-level grades the stagnation of the music reading skill can be attested. Students ran into difficulties with the tasks of the meter and time signature just like in the pilot test. Less than 50% of the students recognized the perfect fifth interval.

As expected, a moderate correlation was found between the achievement in the map reading test and the achievement in the music reading tests. According to the results, there is a moderate correlation between the students' achievement in the map reading test and the achievements in all subtests. On the basis of the results, we can claim that 10-14 year-old students' spatial abilities correlate with their music reading skills.

When examined the background variables, no significant correlations were found between the mothers' highest level of education and the students' achievement in the music reading test. Our expectations that the girls' results were significantly better than those of the boys in each grade were justified.

Comparing the two school types, significant differences were observed between the test achievements in each grade. The validity of the tests is supported by the better results of music school students in contrast to mainstream school students, and the significant correlation between music reading skill level and the amount of time spent with active musical activities.

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9. Conclusions

Many studies have been conducted to examine the transfer effects of music training on brain development and cognition in children. These studies have indicated positive transfer effects of musical skills on a number of cognitive domains. Based on the convincing results, there is more and more research in the field of music reading. However, only a few of them aim to assess students' reading skills.

Our research was the first attempt to examine students' music reading skills with the use of the latest digital technologies in Hungary and in Luxembourg. This research into music reading was conducted on the basis of Erősné's Model of Basic Musical Skills (1992), the requirements of solfege and music education of National Core Curriculum and the Kodály concept. Kodály's music reading exercises formed the basis for testing students' reading skills during my eye tracking research.

In the empirical research, I conducted three eye-tracking studies, which were followed by cross-sectional online measurements. In the eye-tracking studies students' silent and loud rhythmic and melody reading skills were analyzed. Findings based on eye-tracking indicated developmental periods in music reading revealed by the heat maps. They show that the ten-year age-level groups read music note-by-note, as opposed to older students who read units.

Just like languages, music also involves different structural elements (sounds, intervals or chords) that are hierarchically organized (Lerdal & Jackendoff, 1983). Musical structures play a crucial role in reading materials, as they enhance and facilitate students reading skills; for instance, the music structure of the exercises by Zoltán Kodály – as demonstrated above. When the same rhythmic pattern, e.g. syncopation, reappears in the same reading exercise, the length of fixation duration drops by almost 50%. It means that the familiarity with the music pattern helps with the music reading process. Despite the simplicity of Kodály's reading exercises, mainstream school students struggled with them, and produced temporally unstable performances.

As hypothesized, the eye fixates the longest on the beginning of the music score, examining the meter and the different key signatures, and also fixates on the more complex rhythms and intervals. In the music score with sol-fa syllables, a progress can be observed: students were becoming better and better at singing and more self-confident as they were getting familiar with the music. Students had fewer fixations towards the end of the score. In general, students observed the sol-fa notation rather than the rhythm or stick notation. They took longer time when the rhythms became more difficult. Students rarely looked at the bar lines, they tended to focus on the middle of the bars.

It was revealed that students use music reading strategies. On a higher, conservatory level they memorize the melody and use it when they sing the verses of an unknown melodic example. On the basis of the number of fixations, we can calculate the means of total fixation durations. The whole musical score of the folksong with text was perceived in 122.52s. The mean of the musical score with the first verse of the folk song was more than one and a half minutes. However, the amount of timed needed to perceive it radically descreased verse by verse. The hypothesis that music structure can have an effect on students' music reading skills was supported by the results again.

Using quantitative and qualitative methods of eye-tracking, it was demonstrated that despite different teaching processes and music methods, the results converge in the different age groups.

The thermal images in the eye-movement test reveal differences between genders. The boys' music reading was found to be less scattered and more focused than that of the girls.

After the eye-tracking studies, online music reading tests were conducted among 10-to14-year old-students. I tested the music reading skills of students who specialize in music and also those of mainstream school students.

A large-scale online assessment was conducted to get more information about students' music reading skills and discover correlations about certain background variables in Hungarian music schools. The reliability of the test battery was good (Cronbach's alpha=0.832). The test matches the difficulty of the skill level of the grades measured. Music school students' achievement was 76.69%, with a standard deviation of 12.35.

There were no significant differencies between the music reading performances of the consecutive grades. However, significant difference was found in the music reading achievement between grade six and grade eight. The findings confirm the results of Study 3, where a developmental trend in music reading was observed between the ages of 10-14. As the music reading test and its subtests strongly correlate with each other, it can be concluded that the measured skill structure is homogeneous.

The relationship between the music reading skills and the background variables was also analyzed. We came to the conclusion that the parents' educational level and their socio-economic background do not affect the students' music reading achievement. The only gender-related difference was detected in the map reading test, where boys performed significantly better, than girls.

It was also observed that music school students' achievement in music reading strongly correlated with their grades in grammar, mathematics, history, English or biology. The results reflect Hollenbeck's (2008) research, which examined instrumentalist students' cognitive, metacognitive and affective skills and found that music education has a positive impact on academic achievement. Music school students' achievement in the music reading test was not correlated with their grades in music. These findings are consistent with Asztalos and Csapó's (2015) study with mainstream school students, which implies that students' musical skills are not assessed properly.

On the other hand, a strong correlation was identified between some components of functional music literacy (the attitudes towards choir or solo performances) and the music reading achievement. So musical activities, and various forms of musical performances can enhance students' reading skills.

A large-scale assessment was carried out in Hungarian mainstream schools, as well. The reliability of the test was 0.839. Primary school students' mean performance on the music reading test was 55.23%, with no significant differences between the four school grades. Asztalos and Csapó's (2015) research, which explored the developmental trends of music perception abilities, support the results. They found that early childhood is an especially sensitive period when musical skills develop the most intensively, and then the process of the development slows down.

In the entire test, primary school students had the best performance in the task with hand sign reading. Almost every student knew the correct answer, which implies that they managed to acquire them successfully in the early school years.

As the music reading test and its subtests strongly correlate with each other, it can be concluded that the measured skill structure is homogeneous, as in the previous studies. A very strong correlation was found between students' music reading achievement and the melody reading subtest, whereas a moderate correlation was discovered between the results of the map reading test the results of the whole tests.

If the results of the two different types of schools are compared, it can be observed that achievement by the music school students was higher on the music reading test. Significant differences were found between the results of the same tasks in the two school types. The validity of the tests is confirmed by the better results of the music school students.

It was also hypothesized that students' visual/spatial skills correlate with music reading skills. As expected, highly significant correlations were found between the achievements of mainstream school students in the music reading test and its subtests and the map-reading test. Music school students achieved significantly better results on each task of the map reading test than primary school students. The results support Hayward and Gromko's (2009) research with pianists, that students' spatial skills can be strong predictors of music reading skills.

To summarize, assessment is an essential component of music teaching and the learning process. With the help of a valid, reliable, and individualized assessment, students are able to develop important musical skills and move closer to reaching the ultimate goal of music literacy instruction: independent musicianship.

9.2. Limitations and directions for future research

Results from the current dissertation should be interpreted with consideration of a number of limitations. First, a replication of the eye-tracking studies, but with a larger sample, may yield a more conclusive outcome. Second, a persistent limitation to eye-movement research is that current technology does not allow for reliable data on whether participants read words correctly during silent music reading. Third, as no temporally controlled performance was used, the question still remains as to whether unexpected musical material has an effect on the music reading skills. Also, lengthening the time period of instruction may also yield more conclusive results. Fourth, exploring the types of errors made by the students might also give us more clarity. Furthermore, with a concentrated focus on cultural, socioeconomic, and linguistic influences, we may get deeper insights into this field.

Further research can involve the online assessment of students' strategy use with eye-tracking. This further research could serve as a basis for developing training programs of music reading comprehension based on the use of reading strategies. The effect of beliefs and strategy use on music reading comprehension can also be investigated, involving the motivational characteristics of students.

A self-developed new EEG device (EEG mind Reader 1.0) can record brain waves, e.g. raw signal, neuroscience defined EEG power spectrum (Alpha, Beta, etc.), eSense meter for Attention, and eSense meter for Meditation. By combining EEG with the Tobii eye-tracking device we can answer the question of whether the time on fixation point was actively spent on concentration during music reading.

Extending online music reading testing across different countries can increase the generalizability of the results. The online platform makes it possible to bridge distances. We tested the music reading skills of primary school students in Luxembourg with an online music test in German. The Spanish version is being developed now.

Hopefully, although the present research is in its initial stage, it will pave the way for new studies in this topic.

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References

Acsády, L. (2003). A zenetanulás idegrendszeri háttere II/1. *Parlando, 1,* 4-9.

Aiello, R. & Williamon, A. (2002). Memory. In: Parncutt R., & McPherson, G. (Eds.), *The science and psychology of music performance.* New York, NY: Oxford University Press.

Almasi, J. F. & Fullerton, S. K. (2012). *Teaching strategic processes in reading.* Guilford, New York.

Altenmüller, E., & Gruhn, W. (1997). *Music, the brain, and music learning. Mental representation and changing activation patterns through learning.* GIML series vol. 2. Chicago: G.I.A

Altenmüller, E., & Gruhn, W. (2002). Brain mechanisms. In: Parncutt R., & McPherson, G. (Eds.), *The science and psychology of music performance.* New York, NY: Oxford University Press.

Anvari, S. H., Trainor, L. J., Woodside, J. & Levy, B. A. (2002). Relations among musical skills, phonological processing, and early reading ability in preschool children. *Experimental Child Psychology, 83.* 111–130.

Asztalos, K., & Csapó, B. (2014). Online assessment of musical abilities in Hungarian primary schools – results of first, third and fifth grade students. *Bulletin of the International Kodály Society, 39*(1), 3-14.

Asztalos, K. & Csapó, B. (2015). Zenei képességek online diagnosztikai mérése. In: Csapó B. & Zsolnai A. (Eds.), *Online diagnosztikus mérések az iskola kezdő szakaszában.* Oktatáskutató és Fejlesztő Intézet. Budapest.

Ayotte, J., Peretz, I., & Hyde, K. (2002). Congenital amusia: A group study of adults afflicted with a music-specific disorder. *Brain: A Journal of Neurology*, *125*(2), 238–251.

Bailey, B. A., & Davidson, J. W. (2005). Effects of group singing and performance for marginalized and middle-class singers. *Psychology of Music, 33*(3), 269-303.

Barkóczi, I., & Pléh, Cs. (1980). Elemzés az általános pszichológia tudományterületéről, különös tekintettel a kognitiv pszichológiára. *Magyar Pszichológiai Szemle, 37,* 556-563.

Barwick, J.,Valentine, E., West, R., & Wilding, J., (1989). Relations between reading and musical abilities. *Educational. Psychology. 59* (2), 253–257.

Bentivoglio, M., & Morelli, M. (2005). The organization and circuits of mesencephalic dopaminergic neurons and the distribution of dopamine receptors in the brain. In: Dunnett, S.B., Bentivoglio, M., Bjorklund, A., & Hokfelt, T. (Eds.), *Dopamine Handbook of Chemical Neuroanatomy,* vol. 21. Amsterdam: Elsevier, 1-107.

Bentley, A. (1966). *Measures of Musical Abilities.* Georges Harrap, London.

Besson, M. & Friederici, A. D. (1998). Language and music: A comparative view. *Music Perception, 16*, 1-9.

Bever, T. G. & Chiarello, R. J. (1974). Cerebral dominance in musicians and non- musicians. *Science*, 185. 537–539.

Bilhartz, T. D., Bruhn, R. A., & Olson, J. E. (2000). The effect of early music training on child cognitive development. *Journal of Applied Developmental Psychology, 20,* 615-636.

Bodza, K., & Vakler, A. (1999). A Magyar népi énekiskola III. Magyar Művelődési Intézet.

Bradley, L., & Bryant, P. (1983). Categorizing sounds and learning to read: A causal connection. Nature, 301, 419-421.

Buzás, Zs. (2012). Információs és kommunikációs technológia alkalmazása a zeneoktatásban - a hagyományostól a modern módszerekig. *Parlando, 54*(5) 20-25.

Buzás, Zs. (2014). The Use of ICT in Conservatory Education In: Szabó, I. (Ed.), 2nd Interdisciplinary Doctoral Conference Pécs: Pécsi Tudományegyetem Doktorandusz Önkormányzat. 169-178.

Buzás, Zs. (2015). Zeneoktatás Luxemburgban: Music education in Luxemburg. *Gradus 2,* (1) 126-133.

Buzás, Zs. (2016). How does the eye read music? – Eye movement and information processes during music reading in age 10-14: Results of an Eye Tracking Test in Germany, Hungary and Luxembourg. In: Sagrillo, D., Nitschké, A., & Brusniak, F. (Eds.), *Leo Kestenberg und musikalische Bildung in Europa.* Weikersheim: Margraf Publishers, 145-160.

Buzás, Zs. & Lele, A. (2013). Zenei képességekkel kapcsolatos előmérés tapasztalatai zeneművészeti szakközépiskolában In: Karlovitz J. T., & Torgyik J. (Eds.), Vzdelávanie, výskum a metodológia = Oktatás, kutatás és módszertan: Neveléstudományi és Szakmódszertani Konferencia. 771.

Buzás, Zs., & Maródi, Á. (2015). A kórusénekés lehetséges transzferhatásainak vizsgálata In: Tóth, Z. (Ed.), *Új kutatások a neveléstudományokban 2014: Oktatás és nevelés – Gyakorlat és tudomány*. (pp. 68-78.) Debrecen, Magyar Tudományos Akadémia Pedagógiai Bizottsága

Buzás, Zs., & Maródi, Á. (2016). Online diagnostic test of music reading skills. In: Hülber, L. (Ed.), I. Oktatástervezési és Oktatás-Informatikai Konferencia Eger: EKF Líceum Kiadó, 14.

Buzás, Zs., & Steklács, J. (2014). The Role of Formal Analysis for Improving Musical Skills: A Study of Eye Movements In: Korom, E., & Pásztor, A. (Eds.) PÉK 2014: XII Pedagógiai Értékelési Konferencia Szeged: SZTE BTK Neveléstudományi Doktori Iskola. 53.

Cain, K. (1996). Story knowledge and comprehension skill. In: Cornoldi, C. & Oakhill, J. V. (Eds.), *Reading comprehension difficulties.* Mahwah, N.J.: Lawrence Erlbaun Associates, 167-192.

Cain, K. (2003). Text comprehension and its relation to coherence and cohesion in children’s fictional narratives. In: *British Journal of Developmental Psychology. 21,* 3, 335-351.

Chafouleas, S. M., Lewandowsic, L. J., Smith, C. R., & Blachman, B. (1997). Phonological awareness skills in children: Examining performance across tasks and ages. *Journal of Psychoeducational Assessment, 15*(4), 334–347.

Choksy, L. (1999). *The Kodály Method I: Comprehensive Music Education.* Upper Saddle River, New Jersey: Prentice-Hall, 1999.

Clarke, E. F. (1988). Generative principles in music performance. In: Sloboda, J.A. (Ed.) *Generative processes in music*. Oxford: Clarendon Press.

Clift, S., & Hancox, G. (2001). The perceived benefits of singing: Findings from preliminary surveys of a university college choral society. *Journal of the Royal Society for the Promotion of Health, 121*(4), 248-256.

Clift, S., & Hancox, G. (2010). Choral singing and psychological wellbeing: Quantitative and qualitative findings from English choirs in a cross-national survey. *Journal of Applied Arts and Health, 1*.1.

Cole, H. (1974). Sounds and signs: aspects of musical notation. Hugo Cole. Oxford University Press.

Cross, I. (1999). Is music the most important thing we ever did? Music, development and evolution. In: Yi, S. W. (Ed.), *Music, mind and science* (pp.10–39). Seoul National University Press, Seoul.

Cross, I., & Morley, I. (2008). The evolution of music: theories, definitions and the nature of the evidence. In: Malloch, S., & Trevarthen, C. (Eds.), Communicative musicality. 61-82. Oxford: Oxford University Press.

Cross, I., & Morley, I. (2013). The evolution of music: theories, definitions and the nature of the evidence. In: Malloch S., Trevarthen, C. (Eds.), *Communicative Musicality: Exploring the Basis of Human Companionship,* (pp. 61-82). Oxford University Press.

Crozier, J. B. (1997). Absolute pitch: Practice makes perfect, the earlier the better. *Psychology of Music*, *25*, 110–119.

Csapó, B. (1992). *Kognitív pedagógia*. Akadémiai Kiadó, Budapest.

Csapó, B. (2000). A tantárgyakkal kapcsolatos attitűdök összefüggései. *Magyar Pedagógia*, (*100)* 3. 343 – 365.

Csapó, B., & Csépe, V. (2012). Bevezetés. In: Csapó, B. & Csépe, V. (Eds.): *Tartalmi keretek az olvasás diagnosztikus értékeléséhez.* (pp.9-16). Nemzeti Tankönyvkiadó, Budapest.

Csépe, V. (2005). A nyelv agyi reprezentációjának változásai és zavarai. *Magyar Tudomány 11*. 13-36.

Csépe, V., Győri, M., & Ragó, A. (2007). *Általános pszichológia 1. Észlelés és figyelem.* Osiris Kiadó, Budapest. 175–186.

Czeizel, E., & Batta, A. (1992). *A zenei tehetség gyökerei*. Arktisz Kiadó, Budapest.

Darwin, C. (1871). *The descent of man and selection in relation to sex*. Murray, London.

Davidson, L. (1989). Observing a yang ch'in lesson: Learning by modeling and metaphor. In Ralph Smith (Ed.)., Journal of Aesthetic Education, 23(1), 85-100.

Dohány, G. (2009). Zenei műveltség értékelése a középiskolás fiatalok körében. *Iskolakultúra 19*(10) 13-23.

Dombi, J. K. E. (1992). *A zenei képességvizsgálatok kézikönyve*. Szeged. Ványtus István Társaság.

Dowling, W. J. (1999). The development of music perception and cognition. In: Deutsch, D. (Ed.), *The Psychology of Music*. (pp. 603–625). Academic Press, London.

Dowling, W., & Harwood, D. (1986). *Music Cognition*. Orlando, FL: Academic Press.

Drake, C. (1993). Reproduction of musical rhythms by children, adult musicians, and adult nonmusicians. *Perception & Psychophysics, 41*, 642-656

Drake, C. (1998). Psychological processes involved in the temporal organization of complex auditory sequences: Universal and acquired processes. *Music Perception, 16,* 11-26.

Ekstrom, R.B., French, J. W., Harman, H. H., & Dermen, D. (1976). *Manual for kit of factor-referenced cognitive tests.* Princeton, NJ: Educational Testing Service.

Elliott, C. A. (1982). The relationships among instrumental sight reading ability and seven selected predictor variables. *Journal of Research in Music Education, 30*(1), 5-14.

Erős, I. (1992). A zenei alapképesség vizsgálata. (pp.183–206) In: Czeizel, E., & Batta, A. (Eds.): *A zenei tehetség gyökerei.* Budapest: Mahler Marcell Alapítvány – Arktisz Kiadó.

Erős, I. (1993). *Zenei alapképesség*. Akadémiai Kiadó, Budapest.

Ester, D. (2001). INTASC: The Universal Language of Teaching. *Indiana Musicator, 56*(4).

Ester, D. (2010). *Sound Connections: A comprehensive approach to teaching music literacy.* Fishers, In: Educational Exclusives.

Everitt, B., 2002. *The Cambridge Dictionary of Statistics. 2. Cambridge,* UK: Cambridge University Press; 2002.

Fernald, A. (1989). Intonation and communicative intent in mothers' speech to infants: Is the melody the message? *Child Development, 60.* 1497–1510.

Flavell, J. H. (1976). Metacognitive aspects of problem solving. In: Resnick, L. (Ed.), *The nature of intelligence.* Hillsdale, NJ: Lawrence Erlbaum.

Flavell, J.H. (1979). Metacognition and cognitive monitoring: A new area of cognitive-developmental inquiry. *American Psychologist, 34*, 906-911.

Flohr, J., & Hodges, D. (2002). Music and neuroscience. In: Cowell, R. & Richardson, C. (Eds.), *The new handbook of research on music teaching and learning: A project of the Music Educators National Conference* (pp. 991-1008). Oxford: Oxford University Press.

Forgeard, M., Winner, E., Norton, A., & Schlaugh, G. (2008). Practicing a musical instrument in childhood is associated with enhanced verbal ability and nonverbal reasoning. *PLoS ONE* 3(10)

Foxton, J. M., Dean, J. L., Gee, R., Peretz, I., & Griffiths, T. D. (2004). Characterization of deficits in pitch perception underlying "tone deafness". *Brain: A Journal of Neurology, 127*(4), 801–810.

Furneaux, S., & Land, M. F. (1999). The effects of skill on the eye-hand span during musical sight-reading. Proceedings of the Royal Society of London, Series B, 266, 2435–2440.

Füller, K. (1974). *Standardisierte Musikalitätstests*. Diesterweg, Frankfurt.

Gembris, H. (2002). The development of musical ability. In: Colwell, R.-Ricardson, C. (Ed.): *The new handbook of research on music teaching and learning* (pp.487–509). Oxford University Press, New York.

Goolsby, T. (1994). Profiles of processing: Eye movements during sightreading. *Music Perceptions, 12.* 97–123.

Gordon, E. E. (1965). *Musical Aptitude Profile Manual.* Houghton Mifflin, Boston.

Gordon, E.E. (1980). *Learning sequences in Music: A Contemporary Music Learning Theory.* Chicago: GIA Publications, Inc.

Gordon, E. E. (1989). *Advanced Measures of Music Audiation*. GIA Publications, Chicago.

Gordon, E.E. (1994). Audiation: Theoretical and practical explanation. *IKS Bulletin 19.* 30-34.

Gordon, E.E. (2007). *Learning sequences in music*. Chicago: GIA Publications, Inc.

Gosselin, N., Samson, S., Adolphs, R., Noulhiane, M., Roy, M., Hasboun, D., Baulac, M. &, Peretz, I. (2006). *Emotional responses to unpleasant music correlates with damage to the parahippocampal cortex.* Brain. 129:2585–2592.

Gósy, M. (2000). A beszédritmus elemzésének egy lehetséges megközelítése. *Magyar Nyelvőr, 124(*3), 273–284.

Gósy, M. (2005). *Pszicholingvisztika.* Budapest: Osiris Kiadó.

Gönczy, L. (2008). Kodály országa – az eltékozolt lehetőségek országa. *Parlando, 50.* 2. 28–31.

Gönczy, L. (2009). Kodály-koncepció: a megértés és alkalmazás nehézségei Magyarországon. *Magyar Pedagógia, 109.* 2.169–185.

Green, A. (1994). Unison versus individual singing and elementary students' vocal pitch accuracy. *Journal of Research in Music Education, 42*, 2. 105-114.

Gromko, J. E. (2005). The effect of music instruction on phonemic awareness in beginning readers. *Journal of Research in Music Education, 53.* 3. 199–209.

Gruhn, W. (1997). Music Learning Produces Changes in Brain Activation Patterns: A Longitudinal DC-EEG-Study, *International Journal of Arts Medicine (IJAM), 5*. 28 - 33.

Gruhn, W. (2003). Do mental speed and music abilities interact? In: Avanzini, G., & Faienza, C. (Eds.), *The Neurosciences and Music* (pp. 485 – 496).New York: Annals of the New York Academy of Sciences vol. 999, New York. 485 – 496

Häikiö, T., Bertram, R., Hyönä, J., & Niemi, P. (2009). Development of the letter identity span in reading: Evidence from the eye movement moving window paradigm. *Journal of Experimental Child Psychology, 102,* 167–181.

Hámori, J. (2002). Az emberi agy és a zene. In: Székelyi, M. (Ed.), *Hang és lélek: Új utak a zene és társadalom kapcsolatában: Zenei nevelési konferencia* (pp.40-42). Budapest: Magyar Zenei Tanács.

Hannon, E. E., Soley, G., & Levine, R. S. (2011). Constraints on infants' musical rhythm perception: Effects of interval ratio complexity and enculturation. *Developmental Science, 14,* 865– 872.

Harwood, D. (1976). Universals in music: a perspective from cognitive psychology. *Ethnomusicology 20*, 521–533

Hatfield, E., Cacioppo, J. T., & Rapson, R. L. (1994). *Emotional contagion*. New York: Cambridge University Press.

Hayward, C. M., & Gromko, J. (2009). Relationships among Music Sight-Reading and Technical Proficiency, Spatial Visualization, and Aural Discrimination. Journal Of Research, *Music Education, 57(1),* 26-36.

Hegedűsné, T. Zs. (2015). A zenei nevelés hatásai. In: Gyöngy, K. (Ed.), *Első lépések a művészetek felé* II. Dialóg Campus Kiadó.

Hegyi, E. (1984). *Stylistic knowledge on the basis of the Kodály concept.* Zoltán Kodály Pedagogical Institute of Music, Kecskemét.

Hillman, S. (2002). Participatory singing for older people: a perception of benefit, *Health Education, 102*(4), 163–171.

Hodges, D. A. (2011). The acquisition of music reading skills. In: *Handbook of Research in Music Teaching and Learning* (pp. 466-471). New York: Schirmer Books.

Hollenbeck, L. (2008). Cognitive, Affective, and Meta-Cognitive Skill Development through Instrumental Music: A positive impact on academic achievement. Educational Resources Information Center.

Hoover, H., Dunbar, S., Frisbie, D., Oberley, K., Bray, G., Naylor, R., Lewis, J., Ordman, V., & Qualls, A. (2003). The Iowa tests. Itasca, IL: Riverside Publishing.

Houlahan, M., & Tacka, P. (2008). A Cognitive Approach to Elementary Music Education. Kodály Today.

Hyde, K. L., Lerch, J. P., Zatorre, R. J., Griffiths, T. D., Evans, A. C., & Peretz, I. (2007). Cortical thickness in congenital amusia: When less is better than more. *Journal of Neuroscience, 27*(47), 13028–13032.

Imberty, M. (1969). *L'acquisition des structures tonales chez l'enfant*. Klincksieck, Paris.

Israel, S. E. (2007). *Using metacognitive assessments to create individualized reading instruction.* Newark, DE: International Reading Association.

Ittzés, M. (2004). Zoltán Kodály 1882–1967: Honorary President of ISME 1964–1967. *International Journal of Music Education, 22.* 2.131–147.

Ittzés, M. (2006). *Zoltán Kodály,* In*: Retrospect.* Kodály Institute. Kecskemét.

Janols, P.E. (1990). *Computers in music teaching*. New Zealand, University of Canterbury. 219-231.

Janurik, M. (2008). A zenei képességek szerepe az olvasás elsajátításában. *Magyar Pedagógia, 108.* 4. 289–318.

Janurik, M. (2010). A zenei hallási képességek fejlődése és összefüggése néhány alapkészséggel 4-8 éves kor között. Doktori értekezés. Szeged: Szegedi Tudományegyetem.

Janurik, M., & Józsa, K. (2013). A zenei képességek fejlődése 4 és 8 éves kor között *Magyar Pedagógia 113*(2), 75-99.

Jordan-DeCarbo, J., & Nelson, J. (2002). Music and early childhood education. In: Colwell, R., & Richardson, C. P. (Eds.), *The new handbook of research on music teaching and learning* (pp. 210-242). New York: Oxford University Press.

Jorgensen, E. R. (1981). School Music Performance Programs and the Development of "Functional Musical Literacy": A Theoretical Model. *College Music Symposium*, 21. 1. 82-93.

Kalmus, H., & Fry, D. B. (1980). On tune deafness (dysmelodia): frequency, development, genetics and musical background. *Ann. Hum. Genet.* 43, 369–383.

Kárpáti, A. (2008). Informatikai módszerek az oktatásban. In: Réthy, E. (Ed.): *A tanítás-tanulás hatékony szervezése. Adalékok a jó gyakorlat pedagógiai alapjaihoz* (pp.113-123). Educatio, Budapest.

Kenny, B. J., & Gellrich, M. (2002). *Improvisation*. In: Parncutt, R. & McPherson, G.E. (Eds.), The Science and Psychology of Music Performance (pp. 117-134). New York: Oxford Univ. Press.

Kinney, H.C., Brody ,B.A., Kloman, A.S., & Gilles, F.H. (1988). Sequence of central nervous system myelination in human infancy. II. Patterns of myelination in autopsied infants. *Journal of Neuropathology & Experimental Neurology*. 217-234.

Kinsler, V., & Carpenter, R. H. S. (1995). Saccadic eye movements while reading music. Vision Research, 35(10), 1447–1458.

Király, Zs. (2012). *Computer-aided Eartraining*. Révai Digitális Kiadó.

Kodály, Z. (1941a). *Énekeljünk tisztán.* Budapest: Magyar Kórus.

Kodály, Z. (1941b). *15 kétszólamú énekgyakorlat.* Budapest.

Kodály, Z. (1943). *333 olvasógyakorlat*. Budapest.

Kodály, Z. (1962). *Ötfokú zene IV. 140 csuvas dallam*. Editio Musica Budapest.

Kodály, Z. (1963). *Kórusok (Vegyeskarok) II. kötet.* Zeneműkiadó Vállalat.

Kodály, Z. (1974). *The Selected Writings of Zoltán Kodály.* Edited by F. Bónus. Trans. L. Halápy & F. Macnicol. London: Boosey and Hawkes.

Kokas, K. (1972). *Képességfejlesztés zenei neveléssel*. Zeneműkiadó, Budapest.

Koyama, M., Wachi, M., Utsuyama M., Bittman, B., Hirokawa K., & Kitagawa M. (2009). Recreational music-making modulates immunological responses and mood states in older adults. *Journal of Medical and Dental Sciences, 56*(2), 57-70.

Kreutz, G., Bongard, S., Rohrmann, S., Grebe, D., Bastian, H.G., & Hodapp, V. (2004). Effects of choir singing or listening on secretory immunoglobulin A, cortisol and emotional state. *Journal of Behavioral Medicine, 2* (6), 623-635.

Krumhansl, C.L. (1990). *Cognitive Foundations of Musical Pitch.* New York: Oxford University Press.

Krumhansl, C.L., & Keil, F.C. (1982). Acquisition of the hierarchy of tonal functions in music. *Memory & Cognition* 10, 243–251.

Lamb, S. J., & Gregory, H. A. (1993). The Relationship between Music and Reading in Beginning Readers. *Educational Psychology*, 13. 19–26.

Larmont, A. (1998). Music, education, and the development of pitch perception: the role of context, age, and musical experience. Psychology of Music, 26(1), 7-25.

Lehmann, A. C., & Ericsson, K. A. (1996). Performance without preparation: Structure and acquisition of expert sight-reading and accompanying performance. *Psychomusicology: Music, Mind & Brain, 15*(1–2), 1–29.

Lehmann, A. C., & V. McArthur. (2002). Sight-reading. In*:* Parncutt, R. & McPherson, G. E. (Eds.), *The science and psychology of music performance: creative strategies for teaching and learning* (pp.135–150). Oxford: Oxford University Press.

Lenneberg, E. H. (1976). *Biological foundations of language*. New York, Wiley.

Lerdahl, F., & Jackendoff, R. (1983). A generative theory of tonal music. Cambridge, MA: MIT Press.

L. Nagy, K. (2004). A kereszttantervi kompetenciák fejlesztésének lehetőségei az ének-zene területén I–II. *Új Pedagógiai Szemle, 54.* (2–3), 3–13.

Loizou, M., & Stuart, M. (2003). Phonological awareness in monolingual and bilingual English and Greek five-year-olds. *Journal of Research in Reading 26*(1). 3-18

Lomax, A. (1977). Universals in song. *World of Music, 19*(1/2), 117–129.

Lookingland, K. .J., & Moore, K.. E. (2005). Functional neuroanatomy of hypothalamic dopaminergic neuroendocrine systems. In: Dunnet, S.B. (Ed.), Handbook of Chemical Neuroanatomy. (pp. 435–523.) Vol. 21. Elsevier; Amsterdam.

Lucchetti, S., Caccio, L., & De Beni, R. (1997). The development of rhythmic perception in eight-to-ten-year-old Italian children. *Bulletin of the Council for Research in Music Education,* 133, 52-56.

Luce, J. R. (1965). Sight-reading and ear-playing abilities as related to instrumental music students. *Journal of Research in Music Education*, 13. 1011– 09.

Lynch, M. P., Eilers, R.E., Oller, D.K., & Urbano, R.C. (1990). Innateness, experience, and music perception. *Psychological Science*. 1, 272–276.

Linnakylä, P. (2007). Finnish reading literacy challenged by cultural change. In: Linnakylä, P. & Arffman, I. (Eds.), *Finnish reading literacy. When quality and equity meet*. Finnish Institute of Educational Research, University of Jyväskylä.

MacDonald, R., Kreutz, G., & Mitchell, L. (2012). *Music, Health, and Wellbeing*. Oxford University Press.

Mann, V., & Stoel-Gamman, C. (1996). Phonological development. In: Fletcher, P., & MacWhinney, B. (Eds.), *The Handbook of Child Language* (pp. 335-359.) Blackwell Publishers, Oxford.

Maródi, Á., Devosa, I., Buzás, Zs., Steklács, J. & Sagrillo, D. (2015). Study of eye movement on selected textbooks In: Max, C., Schiltz, C., Reuter, B., Pit-ten-Cate, I., Weber, J-M., Siry, C. & Annet, S. (Eds.), EAPRIL 2015 Conference Luxembourg: University of Luxembourg. 34.

McAdams, S., & Giordano, B. L. (2009). The perception of musical timbre. In: Hallam, S., Cross, I., & Thaut, M. (Eds.), *The Oxford handbook of music psychology* (pp. 72–80). Oxford, UK: Oxford University Press.

McConkie, G. W. (1979). On the Role and Control of Eye Movements in Reading, In: Kolers, P.A., Wrolstad, M., & Bouma, H. (Eds.), *Processing of Visible Language I.* New York: Plenum Press.

McConkie, G. W., Zola, D., Grimes, J., Kerr, P. W., Bryant, N. R., & Wolff, P. M. (1991). Children's eye movements during reading. (pp.251–270.) In: Stein, J. F. (Ed.), *Vision and Visual Dyslexia*. Boston, MA: CRC Press.

McPherson, G. E. (1997). 'Cognitive Strategies and Skills Acquisition in Musical Performance', *Council for Research in Music Education*, 133, 64–71.

McPherson, G. E. (2005). From child to musician: skill development during the beginning stages of learning an instrument. *Psychology of Music, 33*(5), 5–35.

Meyer, L. B. (1998). A Universe of Universals. Leonard B. Meyer. *The Journal of Musicology*, 16. 1, Winter, 3-25.

Michel, P. (1964). *Zenei képesség, zenei készség*. Budapest. Zeneműkiadó.

Moles, A. (1966). *Information Theory and Aesthetic Perception*. University of Illinois Press

Moore, J. K., & Linthicum, F. H. Jr. (2007). The human auditory system: a timeline of development. *International Journal of Audiology 46*, 460–478.

Morley, I. (2002). Evolution of the physiological and neurological capacities for music. *Cambridge Archaeological Journal,12*(2),195–216.

Morrison, S. J., & Fyk, J. (2002). Intonation. In: Parncutt R., & McPherson, G. E. (Eds.), *The Science and Psychology of Music Performance.* (pp.183-198.). New York, NY: Oxford University Press.

Morrison I., & Clift, S. (2012). *Singing and Mental Health*. Sidney De Haan Research Centre for Arts and Health, Canterbury, UK. 3-15.

Nemzeti Alaptanterv (2012), A Kormány 110/2012. (VI. 4.) Korm. rendelete. *Magyar Közlöny, 66*, 10635–10847.

Nemes, K. (2001). A relatív szolmizáció mint a zenei gondolkodás eszköze. In: Ittzés, M. (Ed.), *A Kodály Intézet IV., jubileumi évkönyve.* Kodály Intézet, Kecskemét. 62–72.

Nielsen, R., Best, T. & Tyler, D. (2011). Vocabulary size is associated with second-language vowel perception performance in adult learners, *Studies in Second Language Acquisition (33)*3, 433-461.

Ojemann, G. A. & Creutzfeldt, O.D. (1987). Language in humans and animals: contribution of brain stimulation and recording. In: Mountcastle, V., Plum, F., & Geiger, S. (Eds.) *Handbook of physiology, the nervous system V, higher functions of the brain*. Williams and Wilkins, Balitmore. 675–699.

Papp, I. (2004). *Nyelvi-zenei percepciók és produkciók neuroanatómiai és fiziológiai reprezentációi*. Doktori disszertáció. Semmelweis Egyetem Nyelvi Kommunikációs Központ.

Paris, S. G., Wasik, B. A., & Turner, J. C. (1991). The development of strategic readers. In: Barr, R., Kamil, M. L., Mosenthal, P., & Pearson, P. D. (Eds.), *Handbook of reading research* Vol. II, (pp. 609-640).

Patel, A. D. (2003). Language, music, syntax and the brain. *Nature Neuroscience, 6*(7), 674-681.

Patel, A. D. (2008). *Music, language and the brain.* New York, NY: Oxford University Press.

Patel, A. & Peretz, I. (1997) Is music autonomous from language? A neuropsychological appraisal. In, I. Deliège & J.A. Sloboda (Eds.), *Perception and cognition of music* (pp. 191-215). Hove: Psychology Press.

Penhune, V. (2011). Sensitive Periods In Human Development: Evidence from musical Training. *Cortex, 47*(9), 1126-1137.

Penttinen, M., Anto, E., & Mikkilä-Erdmann, M. (2012). Conceptual change, text comprehension, and eye movements during reading. Research in Science Education

Peretz, I. (2001). Music perception and recognition. In: Rapp, B. (Ed.), *The Handbook of Cognitive Neuropsychology* (pp. 519-540). Hove: Psychology Press.

Peretz, I., Champod, A. S., Hyde, K., Avanzini, G., Faienza, C., & Minciacchi, D. (2003). Varieties of musical disorders: The Montreal Battery of Evaluation of Amusia. In: Avanzini, G., Faienza, C., Minciacchi, V., Lopez, L., & Majno, M. (Eds.), *The neurosciences and music* (pp. 58–75). New York, NY: New York Academy of Sciences.

Peretz, I., & Coltheart, M. (2003). Modularity of music processing. *Nature Neuroscience, 6*, 688-691.

Peretz, I., & Zatorre, R. J. (2005). Brain organization for music processing. *Annual Review of Psychology, 56*, 89-114.

Peretz, I., Cummings, S., & Dubé, M. P. (2007). The genetics of congenital amusia (or tone-deafness): A family aggregation study. *American Journal of Human Genetics, 81*, 582-588.

Perfetti, C. A. (1985). *Reading Ability*. New York. Oxford University Press.

Perfetti, C. A. (1994). Reading, learning and instruction. In: Husen T., & Postlethwaite, T. N. (Eds.), *The International Encyclopedia of Education* (Second Edition). Oxford: Pergamon.

Perney, J. (1976). Musical tasks related to the development of the conservatorium of musical time. *Journal of research in Music Education*, 24, 159-168.

Pethő, V. (2011). Kodály Zoltán és követői zenepedagógiájának életreform elemei. Doktori értekezés. Szegedi Tudományegyetem.

Phillips, K. H., & Aitchison, R. E. (1998). The effects of psychomotor skills instruction on attitude toward singing and general music among students in grades 4-6. *Bulletin of the Council for Research. In: Music Education,* 137, 32-42.

Plaza, M. (2001). The interaction between phonological processing, syntactic awareness and reading: a longitudinal study from Kindergarten to Grade 1. *First Language 21*(3), 3-24.

Pléh, Cs. (1998). *A mondatmegértés a magyar nyelvben.* Budapest: Osiris

Prensky, M. (2001). Digital Natives, Digital Immigrants, Part II: Do They Really Think Differently? *On the Horizon,* (9)6, 15–24.

Pressing,, J. (1984), Cognitive processes in improvisation. In Crozier, W. R. & Chapman, A. J. (Eds.), *Cognitive processes in the perception of art* (pp. 345-363). NorthHolland, Amsterdam.

Pressley, M. (2002). Metacognition and self-regulated instruction. In: Farstrup, A., & Samuels, S. (Eds.), *What research has to say about reading instruction* (pp. 291-309). Newark, DE: International Reading Association.

Pressley, M., & Afflerbach, P. (1995). *Verbal reports of reading: The nature of constructively responsive reading.* Hillsdale, NJ: Erlbaum.

Rayner, K.. (1978). Eye movements in reading and information processing. *Psychological Bulletin,* 85. 618-666.

Rayner, K., & Pollatsek, A. (1989). *The psychology of reading,* New York: Prentice-Hall.

Revákné, M. I. (2003). A természettudományos problémamegoldás és befolyásoló tényezőinek összefüggései a középiskolában. PhD-értekezés, Debrecen.

Révész, G. (1946). *Einführung in die Musikpsychologie*. Francke, Bern. Rogers 2004

Sagrillo, D. (2012). Music Education in Luxembourg: A Critical Rewiew. *International Aspects of Music Education,* 1, 76.

Sagrillo, D. (2016). Solfége and Musical Sight Reading Skills in a European Context. In: Brusniak, F. (Ed.), *Würzburger Hefte zur Musikpädagogik*. 8. Margraf Publishers GmbH.

Salimpoor, V. N., Benovoy, M., Larcher, K., Dagher, A. & Zatorre, R. J. (2011). Anatomically distinct dopamine release during anticipation and experience of peak emotion to music. *Nature Neuroscience,14*(2), 257-262.

Savage, J. (2005). Working towards a theory for music technologies in the classroom: how pupils engage with and organise sounds with new technologies. *British Journal of Music Education,* 22. 167-180.

Schellenberg, E.G. (2006). Long-term positive associations between music lessons and IQ. *Journal of Educational Psychology, 98*, 457-468.

Schellenberg, E. G. & Trehub, S .E. (1994). Frequency ratios and the discrimination of pure tone sequences. Perception and Psychophysics, 56, 472–478.

Schellenberg, E. G. & Trehub, S. E. (1996). Natural musical intervals: Evidence from infants listeners, *Psychological Science,* 7. 272–277.

Schmuckler, M. A. (1989). Expectation in Music: Investigation of melodic and harmonic processes. *Music Perception*, 7, 109-150.

Schmuckler, M. A. (1990). The performance of global expectations. *Psychomusicology,* 9, 122-147.

Seashore, C. E. (1919). *Seashore measures of musical talent.* New York: Columbia Gramophone Company.

Seashore, C.B., Lewis, C. & Saetveit, J.G. (1960). Seashore Measure of Musical Talent. Manual. New York: Psychological Corporation.

Shuter-Dyson, R. (1999). Music ability. In: Deutsch, D. (Ed.), *The Psychology of Music.* Academic Press, London. 627–652.

Siklós, A. (1923). *Zenei formatan – Alaktan.* Rozsnyai Károly Könyv- és Zeneműkiadó. Budapest.

Sloboda, J. (1974). The eye-hand span – an approach to the study of sight-reading. *Psychology of Music (2*)2. 4-10.

Sloboda, J. A. (1976). Visual perception of musical notation: Registering pitch symbols in memory. *Quarterly Journal of Experimental Psichology*, 28. 1–16.

Sloboda, J. (1984). Experimental studies of music reading: a review. *Music Perception: An Interdisciplinary Journal, 2*(2), 222–236.

Sloboda, J. A. (1985). *The musical mind: The cognitive psychology of music*. Oxford, Clarendon Press.

Schnotz, W. & Molnár, E. K. (2012). Az olvasás-szövegértés mérésének társadalmi és kulturális aspektusai. In: Csapó, B. & Csépe, V. (Eds.): *Tartalmi keretek az olvasás diagnosztikus értékeléséhez az első hat évfolyamon*. (pp. 79-128). Budapest: Nemzeti Tankönyvkiadó.

Stein, D., & Glenn, R. (1982). Solo voice. In: *The Science & Psychology of Music Performance*. Creative Strategies for Teaching and Learning.

Sundberg, J., Prame, E., & Iwarsson, B. (1996). Replicability and accuracy of pitch patterns in professional singers. In: Davis, P. J., & Fletcher, N. H. (Eds.), Vocal fold physiology, controlling complexity and chaos (pp.291-306) San Diego, CA: Singular Publishing Group.

Surányi, S., Csépe, V., Richardson, U., Thomson, J., Honbolygo, F., & Goswami, U. (2009). Sensitivity to rhythmic parameters in dyslexic children: A comparison of Hungarian and English. *Reading & Writing,* 22, 41–56.

Swain, J. (1997). *Musical languages*. New York: Norton

Szende, O. (1977). *Intervallic hearing: its nature and pedagogy.* Budapest: Akadémiai Kiadó.

Székácsné, V. M. (1980). *A művészeti nevelés hatásrendszere*. Budapest: Akadémiai Kiadó.

Szőnyi, E. (1954). *A zenei írás-olvasás módszertana*. 3 Editio Musica Budapest.

Takeuchi, A. H. & Hulse, S. H. (1993). Absolute pitch. *Psychology Bulletin,* 113, 345–361.

Teplov, B. M. (1947). Psychology of Music and Musical Abilities [Психология музыки и музыкальных способностей]. Moscow (in Russian).

Teplov, B. M. (1960). *A zenei képességek pszichológiája*. Tankönyvkiadó, Budapest.

Thompson, W. F. & Schlaug, G. (2015). The Healing Power of Music. New therapies are using rhythm, beat, and melody to help patients with brain disorders recover language, hearing, motion and emotion. *Scientific American Mind,* March/April. 33-40.

Trainor, L. (2005). Are there critical periods for musical development? *Developmental Psychobiology*, 46. 262-278.

Trainor, L. J. & Trehub, S. E. (1992). A comparison of infants' and adults' sensitivity to Western musical structure. *Journal of Experimental Psychology: Human Perception and Performance,* 18. 394–402.

Trainor, L. J. & Trehub, S. E. (1993). What mediates infants' and adults' superior processing of the major over the augmented triad? *Music Perception, 11*(2), 185–196.

Tramo, M. J., Cariani, P. A., Delgutte, B., & Braida, L. D. (2003). In: Peretz, I., Zatorre, R., (Eds.), The Cognitive Neuroscience of Music. Oxford, NY: Oxford University Press, 127–151.

Trehub, S. E. (2003). The developmental origins of musicality. *Nature Neuroscience*, 6, 669–673.

Trehub, S. E. (2015). Infant musicality, In: Hallam, S., Cross, I., & Thaut, M. (Eds.), *The Oxford Handbook of Music Psychology*, 2nd Edition Oxford: Oxford University Press.

Trehub, S. E., Unyk, A. M., & Trainor, L. J. (1993). Adults identify infant-directed music across cultures. *Infant Behavior and Development*, 16, 193–211.

Truitt, F. E., Clifton, C., Pollatsek, A., & Rayner, K. (1997). The perceptual span and the eye-hand span in sight reading music. *Visual Cognition, (4*)2, 143–161.

Turmezeyné, H. E. (2007). A zenei ismeretek és képességek fejlődése az alsó tagozatos életkorban. PhD-dissertation. Debreceni Egyetem Pszichológiai Intézete, Pszichológiai Doktori Program, Debrecen.

Turmezeyné, H. E. (2009). A zenei tehetség és az általános intellektuális képességek kapcsolata. *Tehetség*, *(17)*3. 7–9.

Turmezeyné, H. E. & Balogh, L. (2009). *Zenei tehetséggondozás és képességfejlesztés.* Kocka Kör Tehetséggondozó Kulturális egyesület, Debrecen és Faculty of Central European Studies, Constantine the Philosopher University, Nyitra.

Turmezeyné, H. E., Máth J., Balogh, L. (2005). A zenei képességek fejlődésének vizsgálata. *Alkalmazott Pszichológia*, *(7)*4, 100–123.

Ulbaek, I. (1998). The origin of language and cognition. In: Hurford, J. R., Studdert-Kennedy, M., & Knight C. (Eds.), *Approaches to the Evolution of Language: Social and Cognitive Bases.* Cambridge: Cambridge University Press.

Unwin, M.M., Kenny, D.T. & Davis, P.J. (2002), The effects of group singing on mood, *Psychology of Music*, 30, 175-185.

van Atteveldt, N. M., Formisano, E., Goebel, R., & Blomert, L. (2004). Integration of letters and speech sounds in the human brain. *Neuron*, *43*(2), 271-282.

Wan, C. Y., & Schlaug, G. (2010), Music making as a tool for promoting brain plasticity across the life span. *The Neuroscientist*, *16*(5), 566-577.

Welch, G. F. (2006), Singing and vocal development. In: McPherson, G. (Ed.), *The Child as Musician: a Handbook of Musical Development*. Oxford University Press, New York. 311–329.

Wheeler, L. (1985), *Orff and Kodaly: Adapted for the Elementary School.* Dubuque, Iowa: Wm. C. Brown.

Wöllner, C., Halfpenny, E., Ho, S., & Kurosawa, K. (2003). The effects of distracted inner hearing on sight-reading. Psychology of Music, *31*(4), 377-389.

Wurtz, P., Müeri, R. M., & Wiesendanger, M. (2009), Sightreading of violinists: Eye movements anticipate the musical flow. *Experimental Brain Research 194*(3), 445–450.

Zadnik, K, (2012). Teaching methods and didactic materials to develop listening abilities in secondary school. V: Konkol, Gabriela Roman (ur.). International aspects of music education. Vol. 1, Teaching and learning processes. Gdansk: The Stanislaw Moniuszko Academy of music in Gdansk.

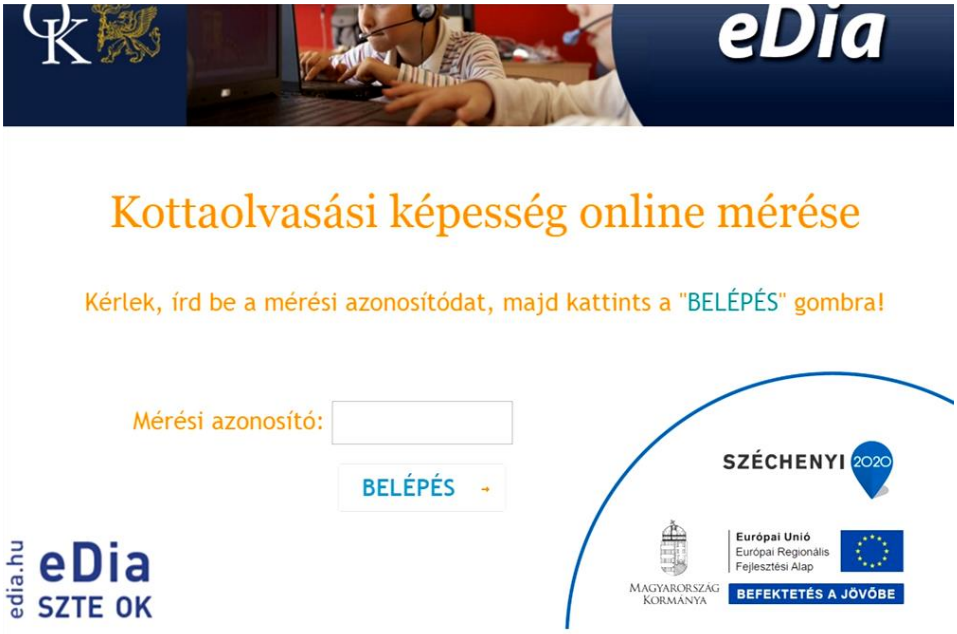
Ziegler, J., & Goswami, U. (2005). Reading acquisition, developmental dyslexia, and skilled reading across languages: A psycholinguistic grain size theory. *Psychological Bulletin, 131*(1), 3-29

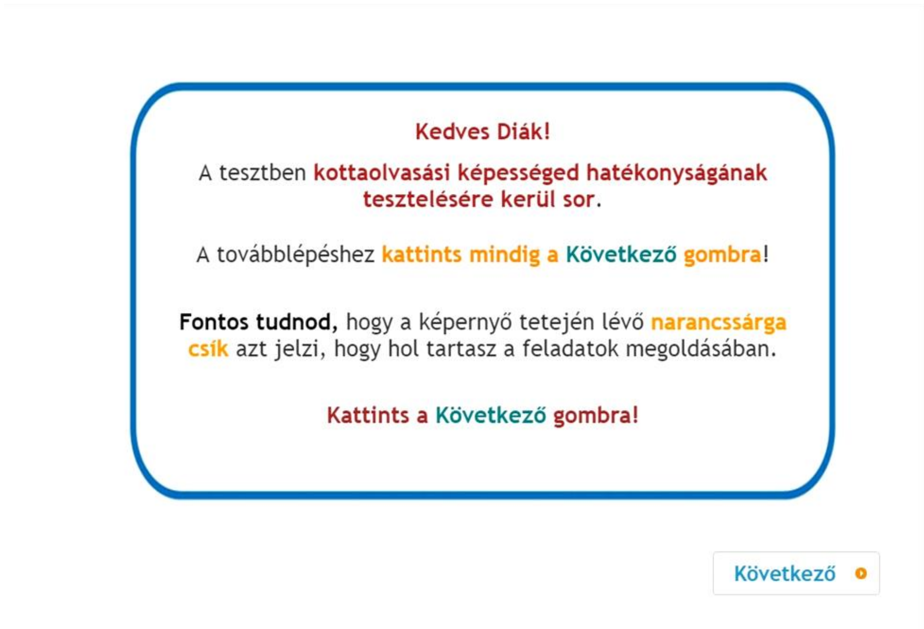
Zola, D, (1984), Redundancy and word perception during reading. *Perception and Psychophisics*, 36, 277.

Appendices

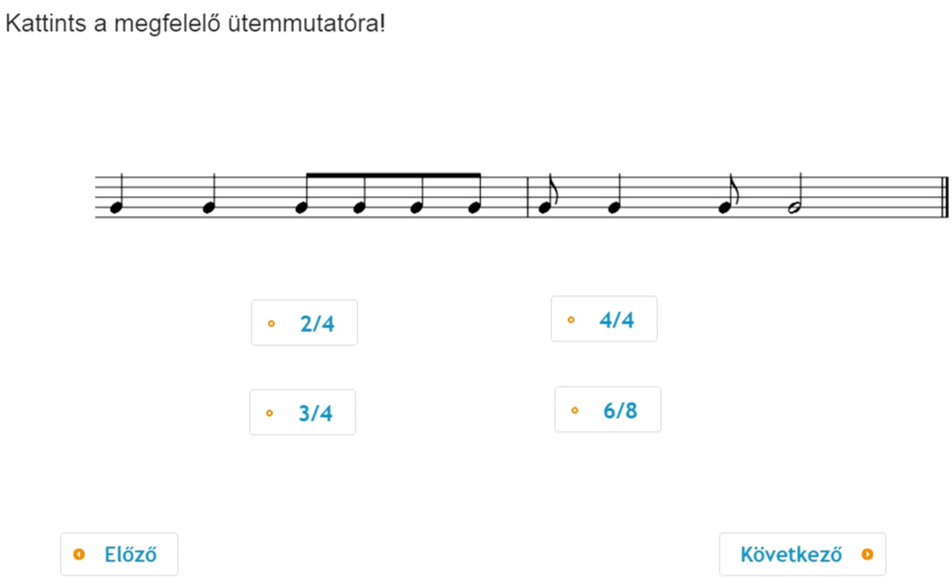
Appendix A. The online music reading test for music school students

Fig. 67 Music reading test



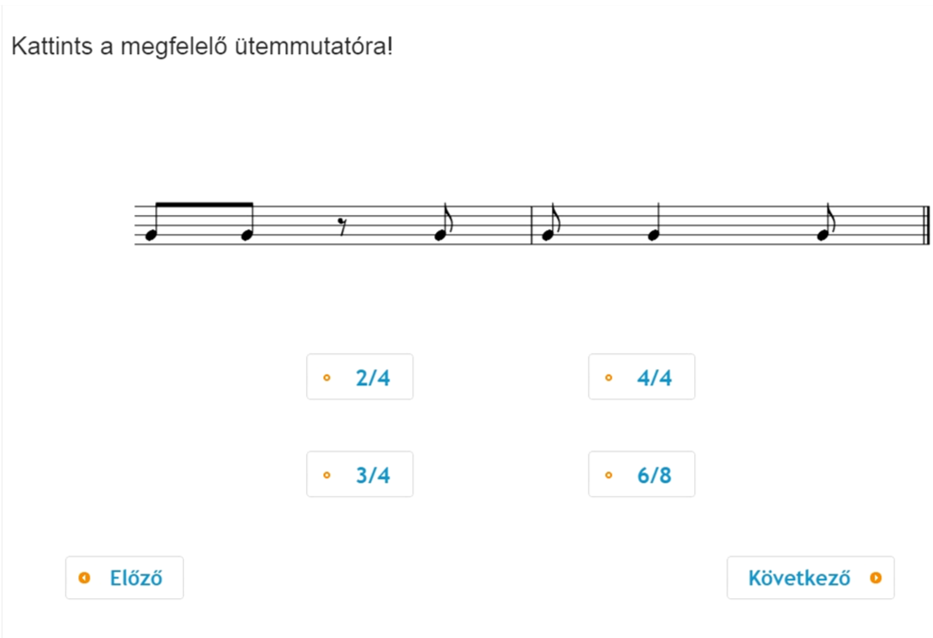


Task 1



The correct answer: 4/4

Task 2

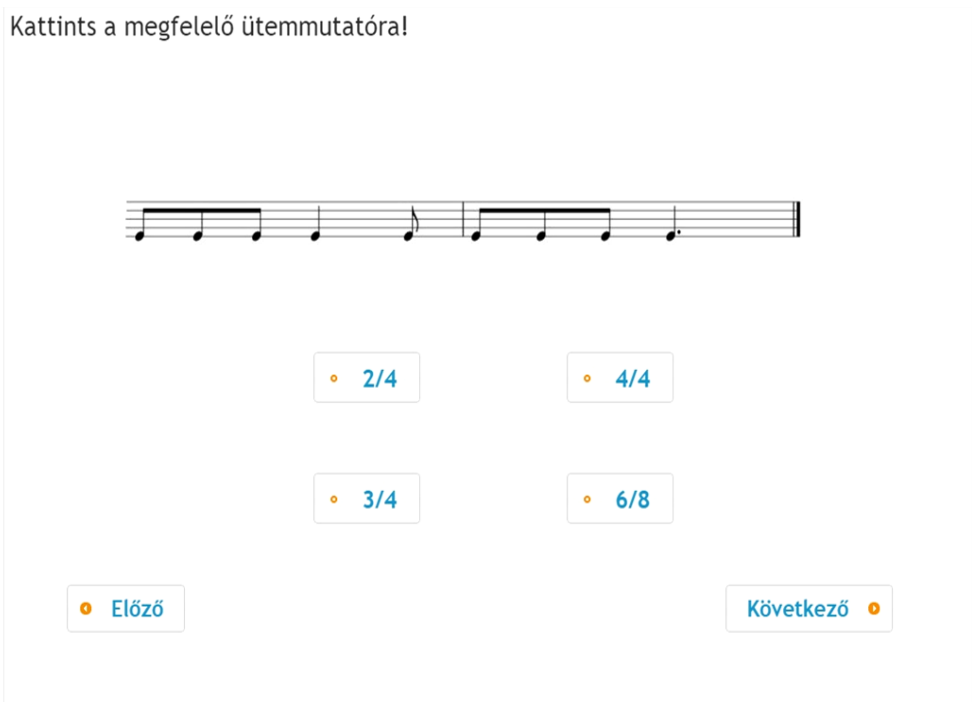


The correct answer: 2/4

Task 3

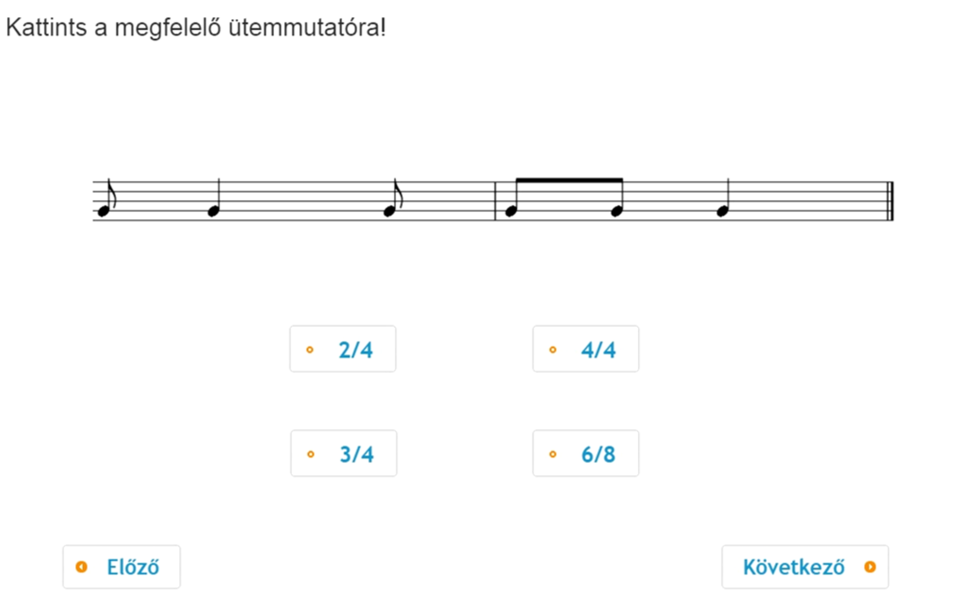
The correct answer: 3/4

Task 4



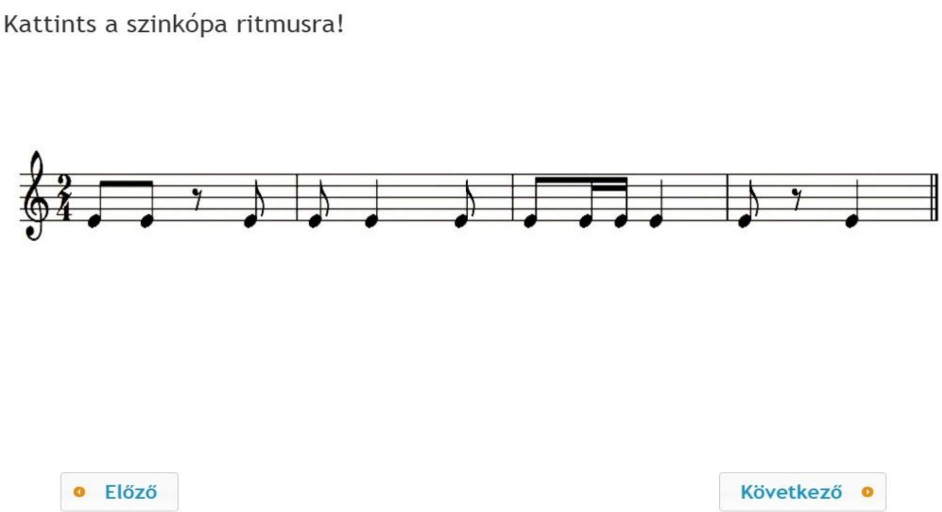
The correct answer: 6/8

Task 5



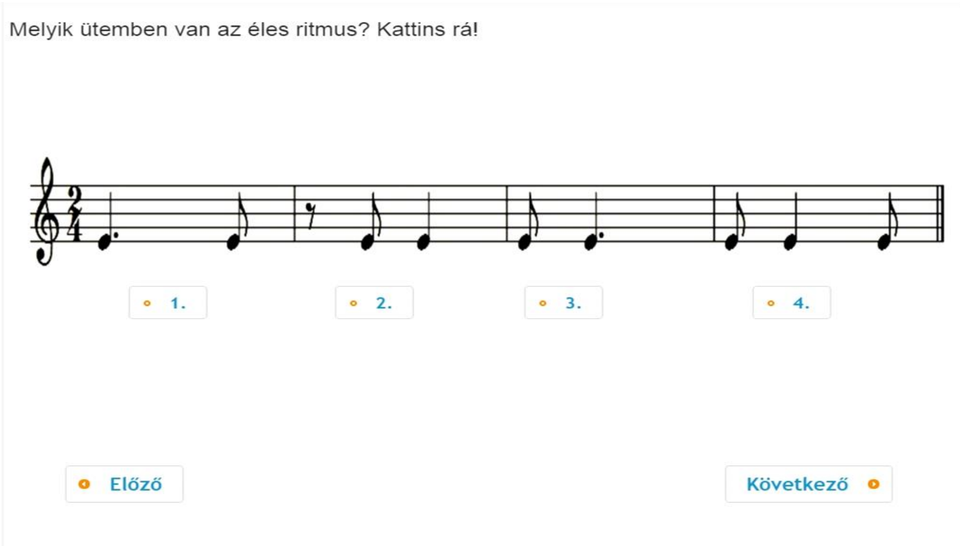
The correct answer: 2/4

Task 6



The correct answer is in the second bar.

Task 7

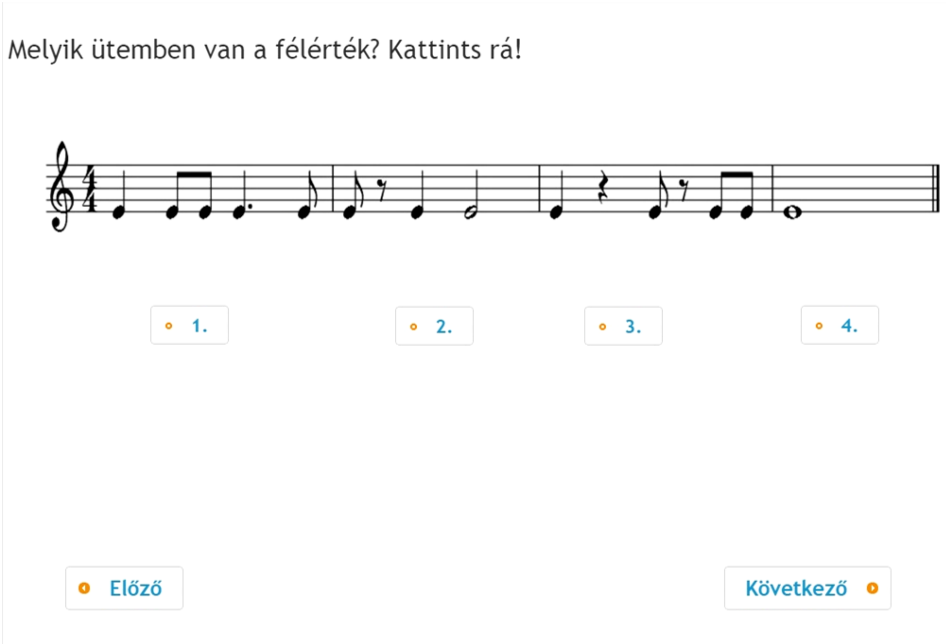


The correct answer: 3.

Task 8

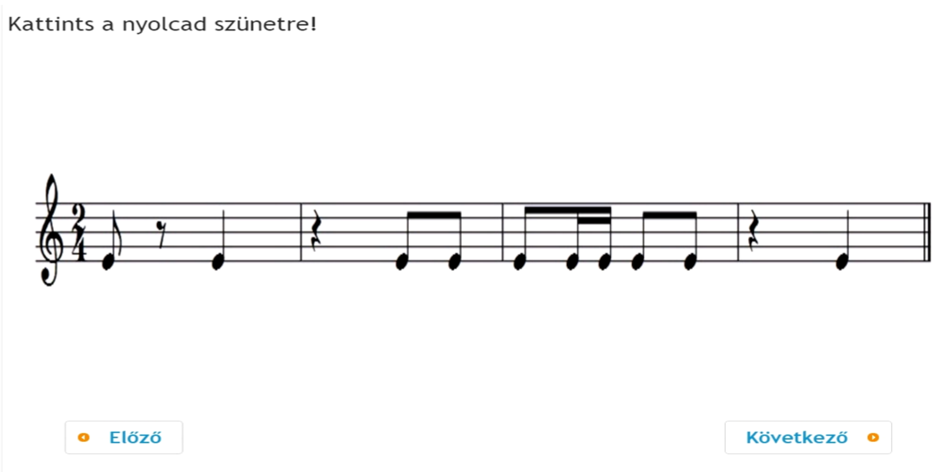
The correct answer: 3.

Task 9



The correct answer: 2.

Task 10

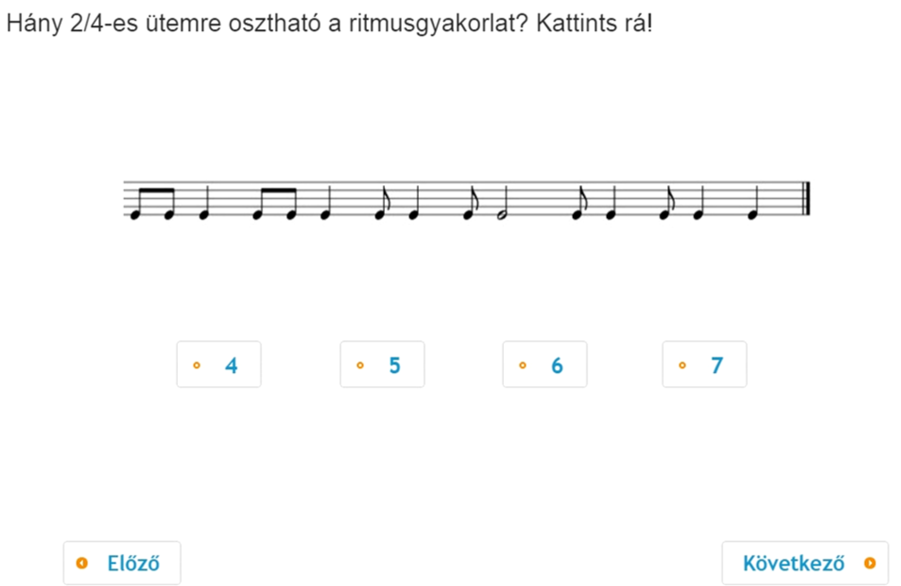


The correct answer is in the first bar.

Task 11

The correct answer: 4.

Task 12



The correct answer: 6.

Task 13

Hány darab 4/4-es ütemre osztható a ritmusgyakorlat? Kattints rá!

3 4 5 6

Előző Következő

The correct answer: 4.

Task 14

Hány 3/4-es ütemre osztható a ritmusgyakorlat? Kattints rá!

3 4 5 6

Előző Következő

The correct answer: 4.

Task 15

Hány darab 3/4-es ütemre osztható a ritmusgyakorlat? Kattints rá!

3

5

4

6

Előző

Következő

The correct answer: 3.

Task 16

Melyik dal kezdődik ezzel a ritmussal? Kattints rá!

Csendes éj, drága szent éj

Hull a pelyhes fehér hó

Előző

Következő

The correct answer: Csendes éj, drága szent éj.

Task 17

Kattints a kulcs nevére!

C | G (violinkulcs) | F (basszus kulcs)

Előző | Következő

The correct answer: G (violinkulcs).

Task 18

Kattints a kulcs nevére!

F (basszuskulcs) | G (violinkulcs) | C

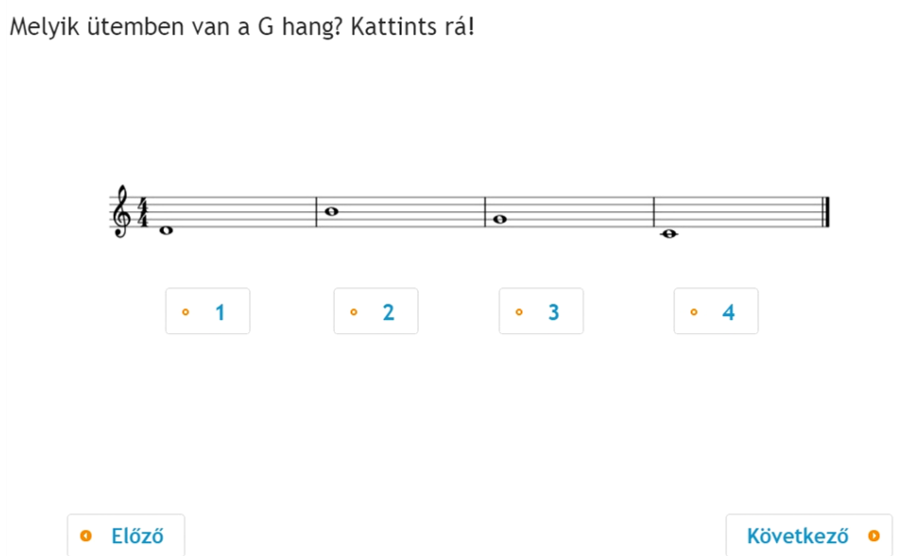
Előző | Következő

The correct answer: F (basszuskulcs).

Task 19

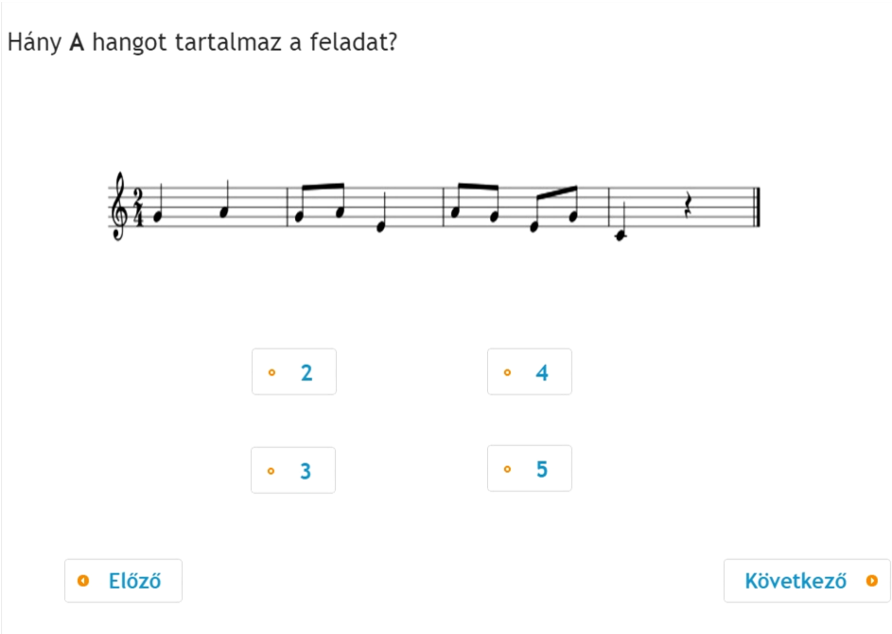
The correct answer: C.

Task 20



The correct answer: 3.

Task 21

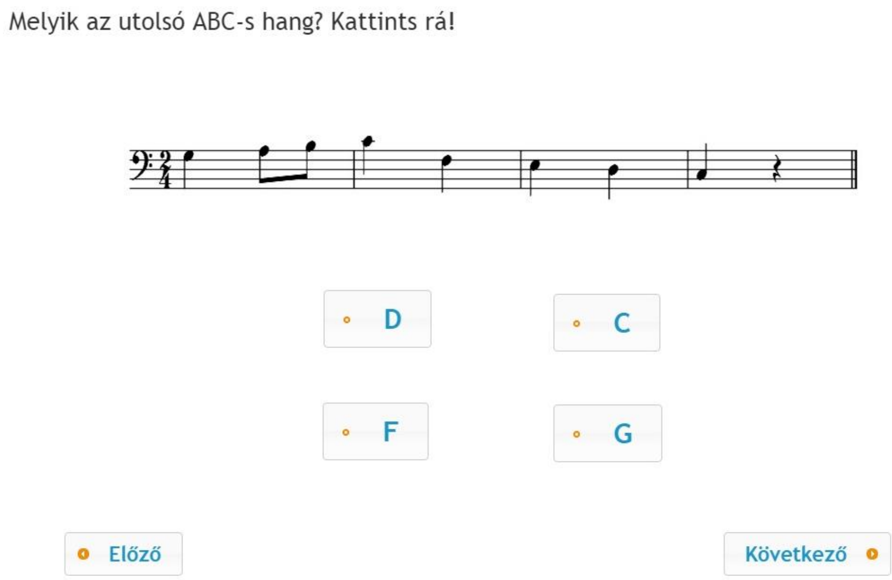


The correct answer: 3.

Task 22

The correct answers are in the first and the third bars.

Task 23



The correct answer: C.

Task 24

The correct answer: D-dúr.

Task 25

Milyen hangnemű a dallam? Kattints rá!

G-dúr | d-moll

D-dúr | g-moll

Előző | Következő

The correct answer: d-moll.

Task 26

Hányadik ütemben van a tiszta kvint (T5)?

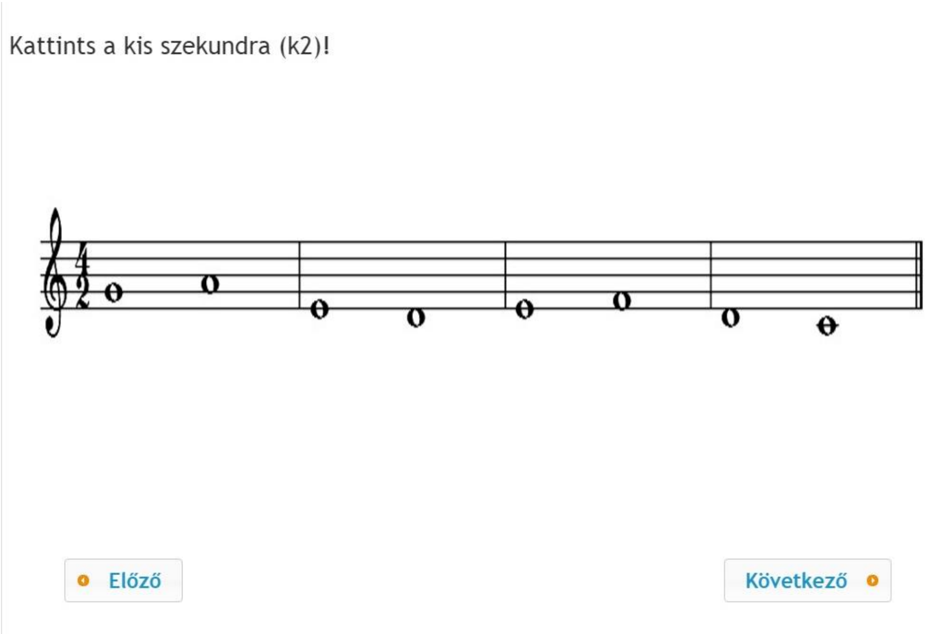
Kattints a helyes válaszra!

1 | 2 | 3 | 4

Előző | Következő

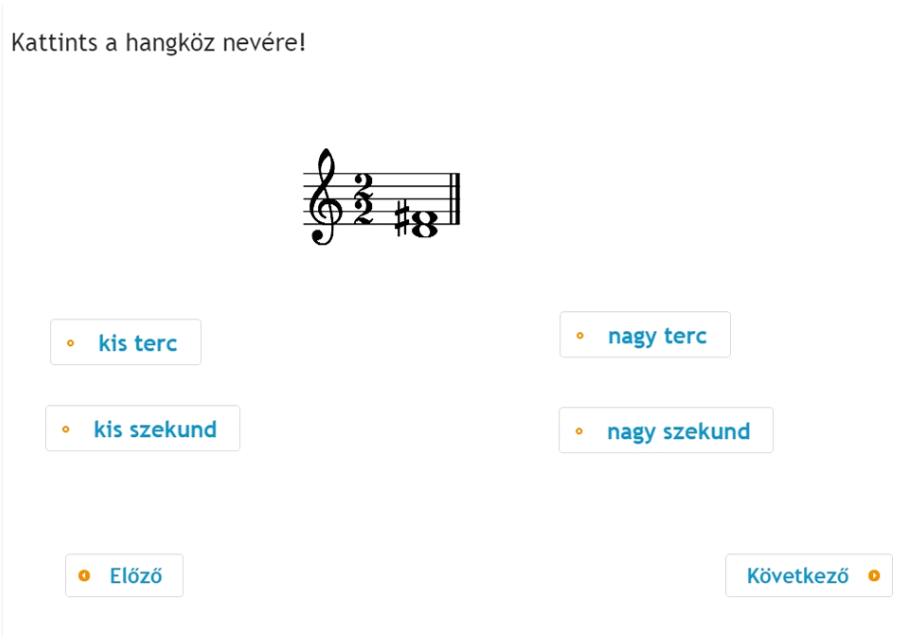
The correct answer: 1.

Task 27



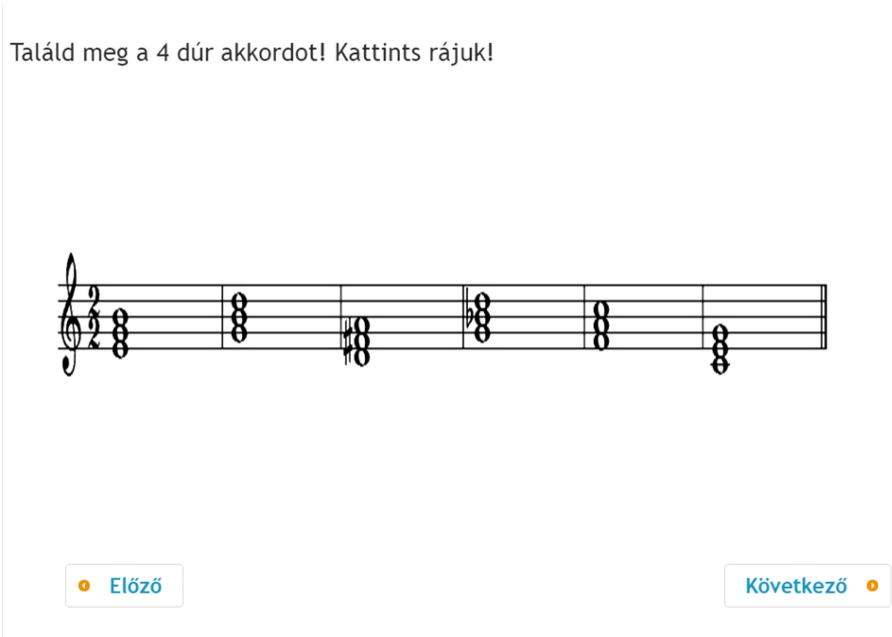
The correct answer: third bar.

Task 28



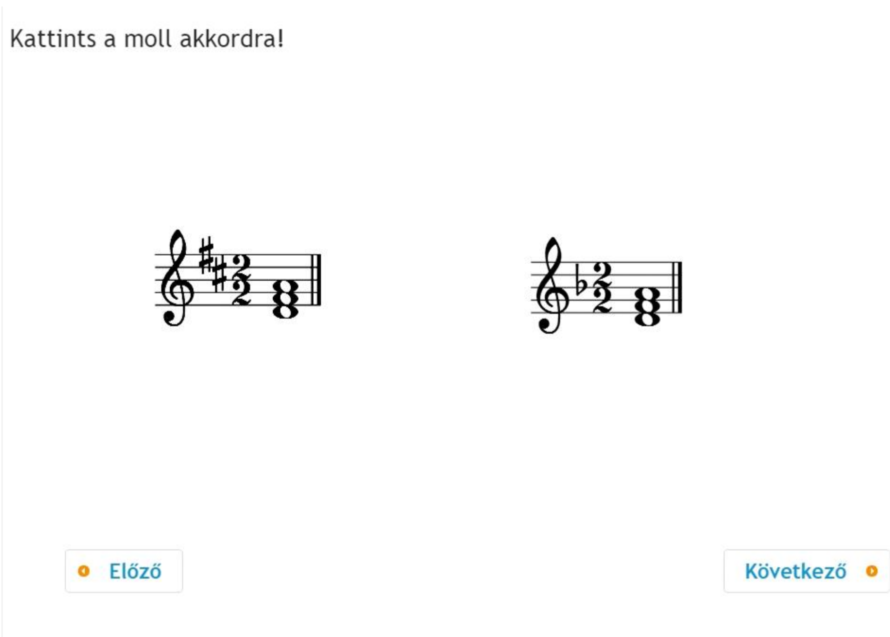
The correct answer: nagy terc.

Task 29



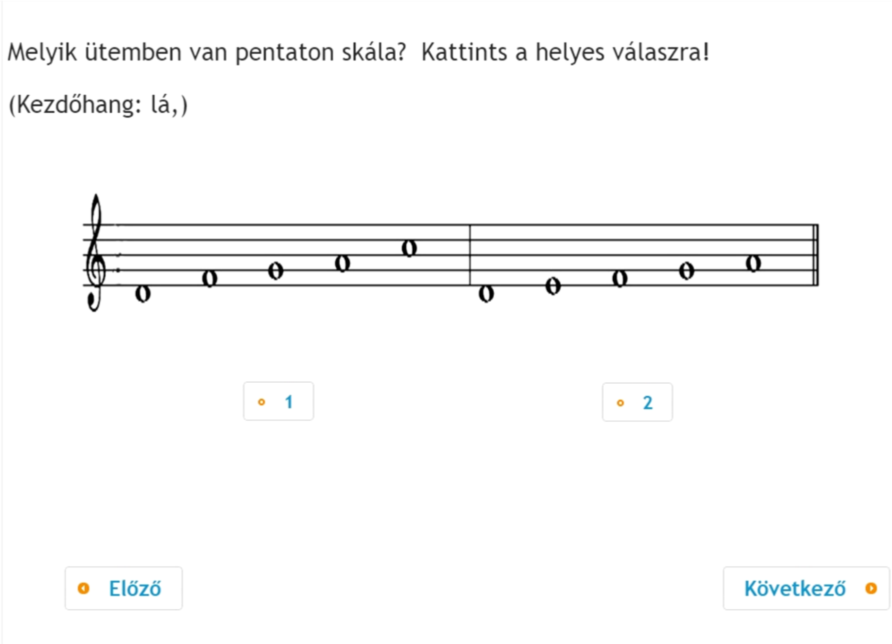
The correct answer: the second, third, fifth and sixth bars.

Task 30



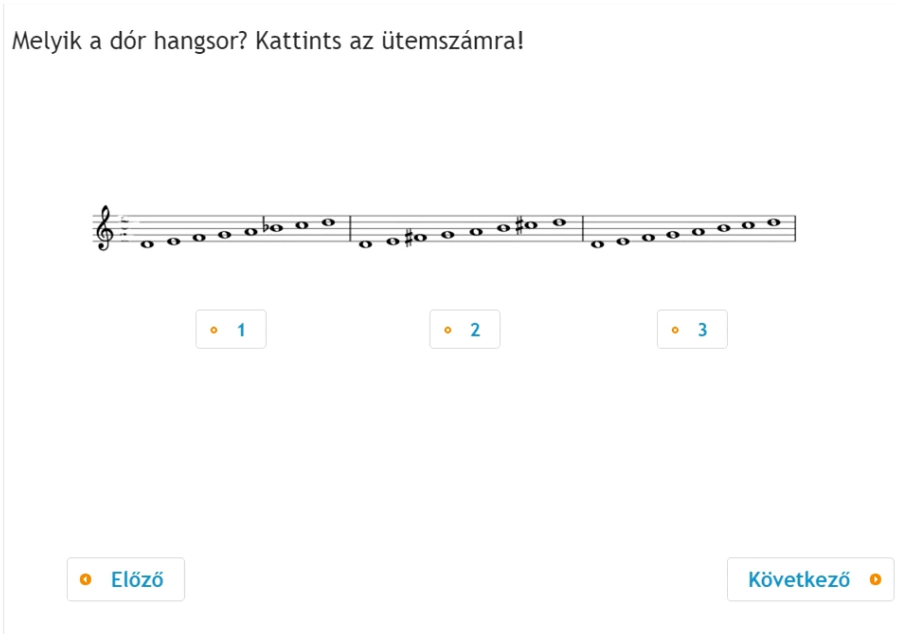
The correct answer: the second one.

Task 31



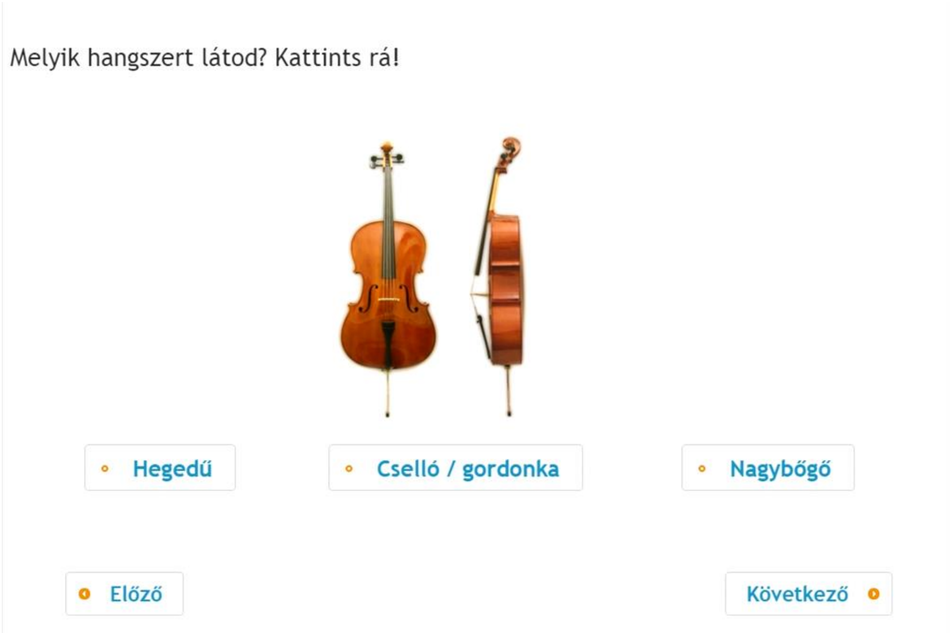
The correct answer: 2.

Task 32



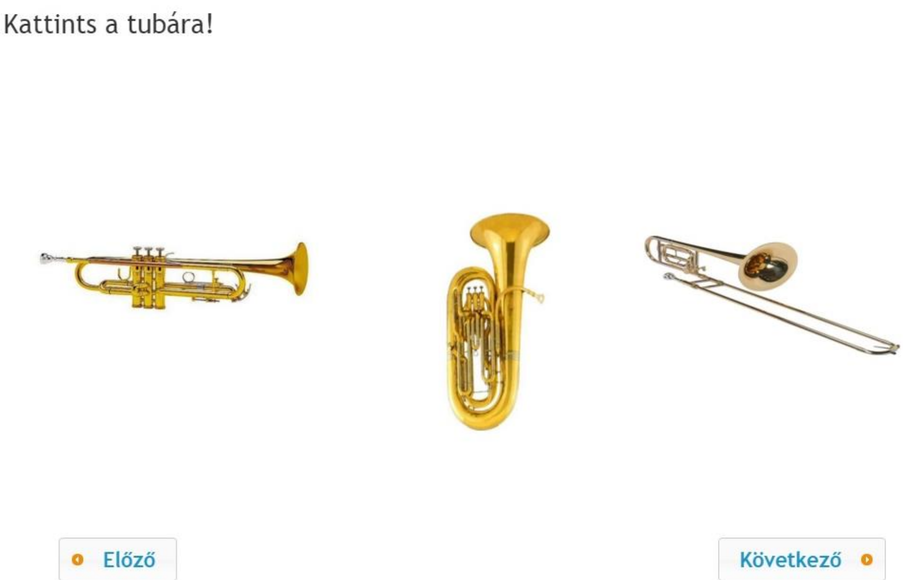
The correct answer: 3.

Task 33



The correct answer: Cselló / gordonka.

Task 34



The correct answer: the second instrument.

Task 35

Mi a dal hangsora? Kattints rá!

(kezdőhang: lá,)

lá-pentaton | dúr | moll

Előző | Következő

The correct answer: lá-pentaton.

Task 36

Kattints arra a zenekartípusra, amelyiket hallod!

vonós zenekar | fúvószenekar | szimfonikus zenekar

Előző | Következő

The correct answer: fúvószenekar.

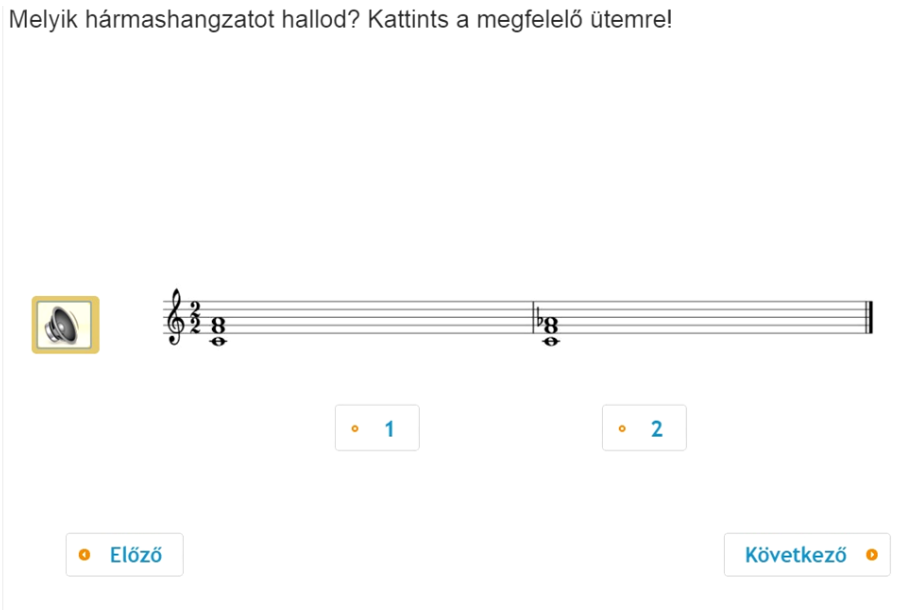
Task 37

The correct answer: klarinét.

Task 38

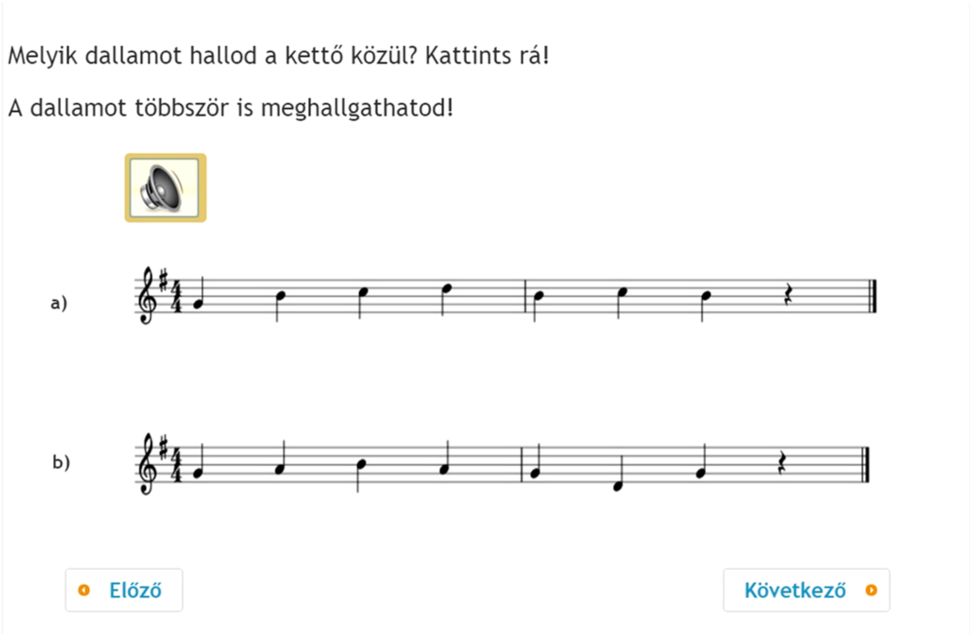
The correct answer is in the first bar.

Task 39



The correct answer is in the second bar.

Task 40



The correct answer: b.

Task 41

Milyen a népdal stílusa? Kattints rá!

régi stílusú

új stílusú

Előző

Következő

The correct answer: régi stílusú.

Task 42

Mi az idézet zenei formája? Kattints rá!

periódus

motívum

kánon

Előző

Következő

The correct answer: periódus.

Task 43

Melyik dalnak a kottáját látod? Kattints rá!

János bácsi, János bácsi | Pál, Kata, Péter | Hull a pelyhes fehér hó

Előző | Következő

The correct answer: János bácsi, János bácsi.

Task 44

Melyik dal kezdődik így? Kattints rá!

Kis kece lányom

Láttál-e már valaha

Megfogtam egy szúnyogot

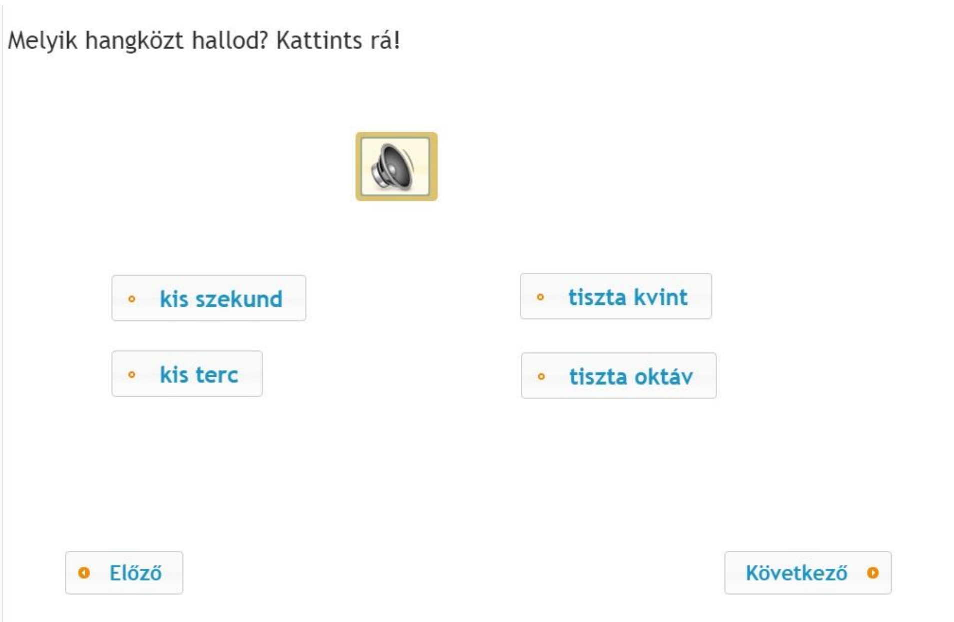
Előző | Következő

The correct answer: Kis kece lányom.

Task 45

The correct answer: tiszta kvint.

Task 46



The correct answer: kis szekund.

Task 47

Melyik zenei válasz illik a zenei kérdéshez? (C=dó)

Kattints rá!

a) 

b) 

Előző

Következő

The correct answer: b.

Task 48

Mit jelent az *allegro* kifejezés? Kattints rá!

lassan

gyorsan

halkan

Előző

Következő

The correct answer: gyorsan.

Task 49

Melyik a szűkített alaphelyzetű hármashangzat? Kattints az ütemszámra!

1. 2 3 4

Előző Következő

The correct answer: 2.

Task 50

Milyen kórustípus énekel? Kattints rá!

gyermekkar nőikar

férfikar vegyeskar

Előző Következő

The correct answer: vegyeskar.

Task 51

The correct answer: a.

Task 52

The correct answer: a.

Task 53

Melyik ütemekre érvényes a *fokozatos halkulás* jele?

Kattints a helyes válaszra!

Előző

Következő

The correct answer: 7-8.

Task 54

Melyik ritmust hallod? Kattints rá!

A ritmust többször is meghallgathatod!

Előző

Következő

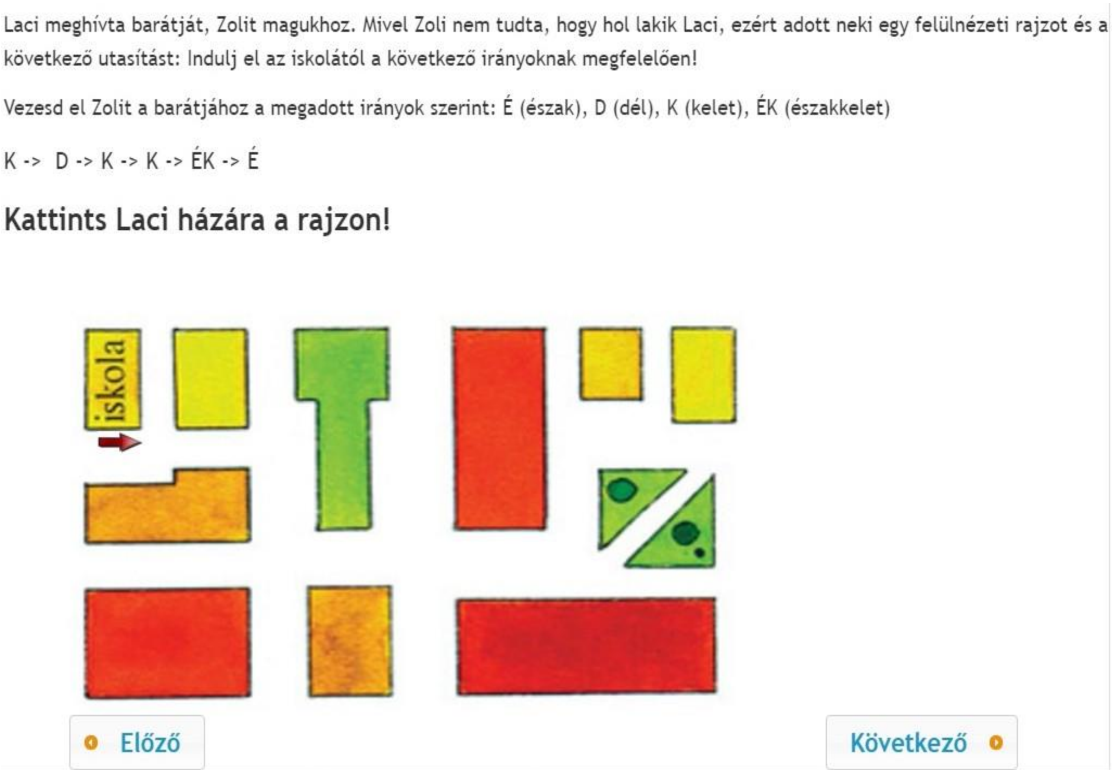
The correct answer: a.

Task 55

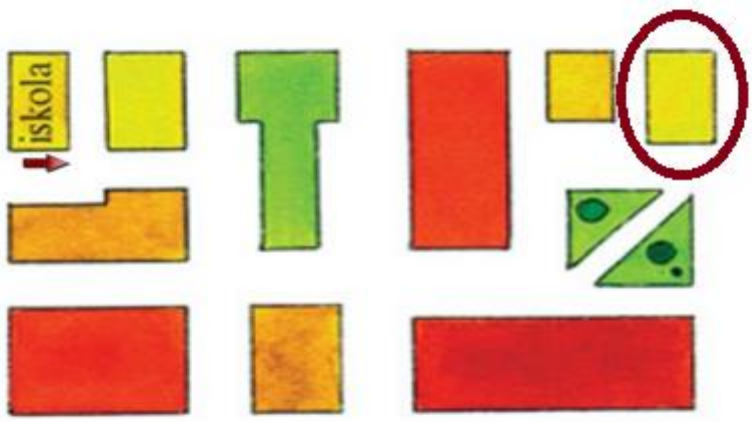
The correct answer: moll skála.

Appendix B. The online map reading tasks

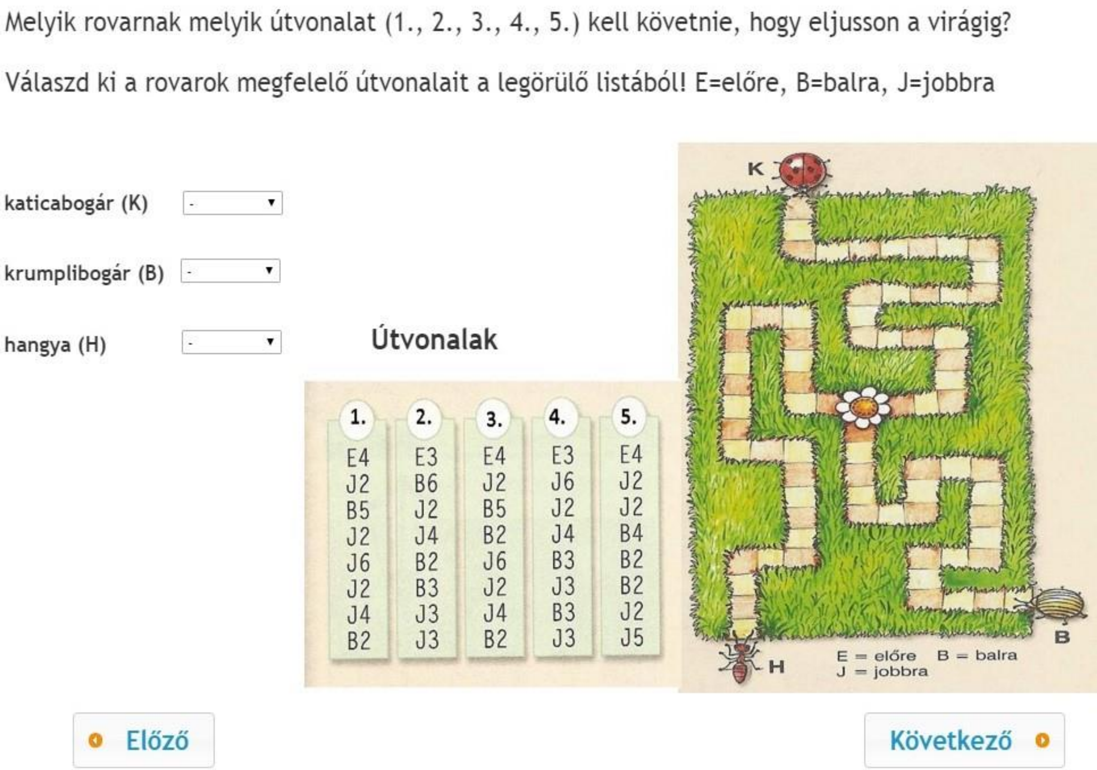
Task 57



The correct answer:



Task 58

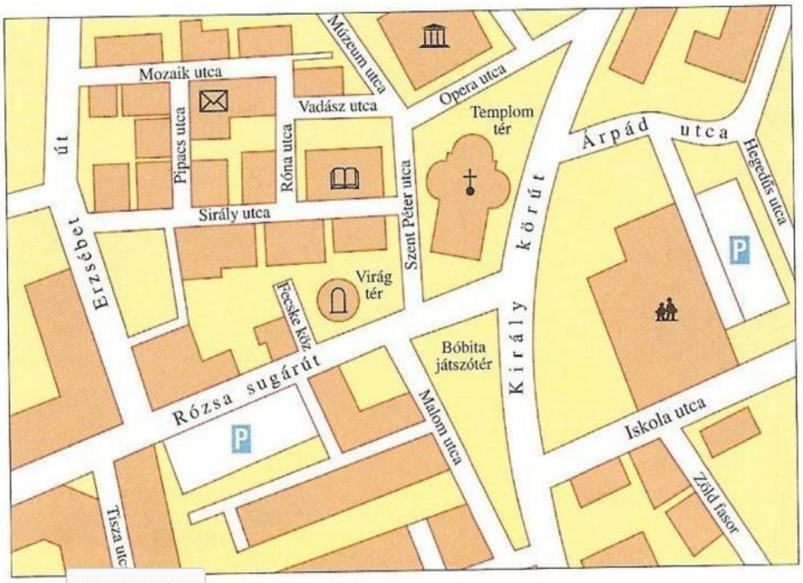


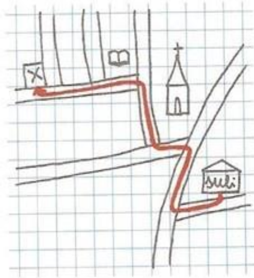
The correct answer: K:2, B:5, H:3.

Task 59

Palkó játszani indult az osztálytársához Gáborhoz. Gábor lerajzolta az útvonalat és a házukat, de elfelejtette megadni a címet. Palkónak a település térképe segített.

Kattints Gábor házára a térképen!

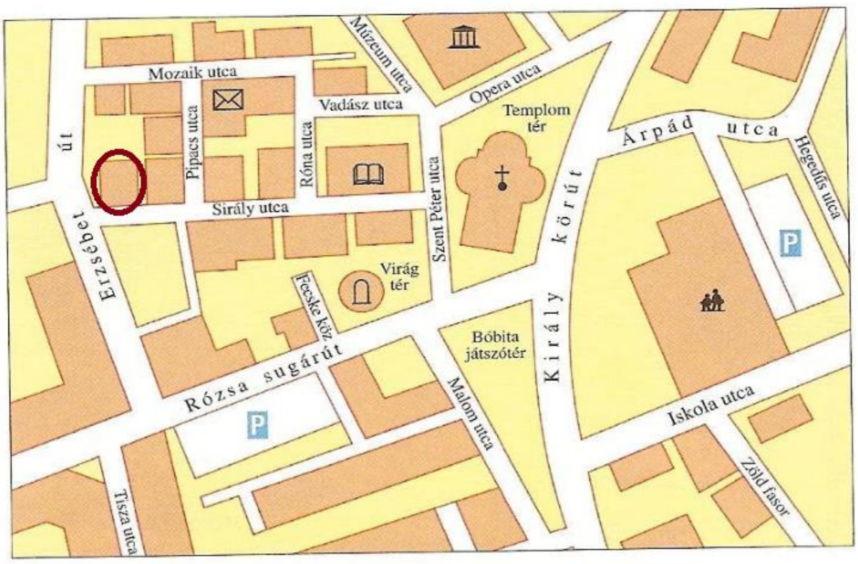




Előző

Következő

The correct answer:



Appendix C The online background questionnaire

Testing the music reading skills of 10-14 year-old students

Questionnaire

01. Hogy érzed, hogyan sikerült megoldanod a feladatokat? *(egy válasz jelölhető)*

a) nagyon jól
b) jól
c) közepesen
d) rosszul
e) nagyon rosszul

02. Kérlek, hogy válaszd ki a nemed! Jelöld a megfelelőt! *(egy válasz jelölhető)*

a) lány
b) fiú

03. Hány éves vagy? Írd a szövegdobozba!

04. Mi édesanyád/nevelőanyád legmagasabb iskolai végzettsége? *(egy válasz jelölhető)*

a) nem fejezte be az általános iskolát
b) általános iskola
c) szakiskola
d) szakmunkásképző
e) érettségi
f) főiskola (felsőfokú alapképzés
g) egyetem felsőfokú mesterképzés
h) nem tudom

05. Mi édesapád/nevelőapád legmagasabb iskolai végzettsége? *(egy válasz jelölhető)*

a) nem fejezte be az általános iskolát
b) általános iskola
c) szakiskola
d) szakmunkásképző
e) érettségi
f) főiskola (felsőfokú alapképzés
g) egyetem felsőfokú mesterképzés
h) nem tudom

06. Milyen típusú településen laksz? *(egy válasz jelölhető)*

a) falu/ község
b) város
c) megyei jogú város
d) főváros

07. Tanulsz szolfézst? *(egy válasz jelölhető)*

a) igen
b) nem
c) tanultam, de már nem

08. Hány éve tanulsz szolfézst? Írd a szövegdobozba!

09. Hány éve jársz zeneiskolába? Írd a szövegdobozba!

10. Milyen hangszeren tanulsz játszani? Többet is megjelölhetsz!
a) zongorán
b) furulyán
c) hegedűn
d) brácsán
e) csellón
f) oboán
g) fuvolán
h) klarinéton
i) trombitán
j) harsonán
k) kürtön
l) tubán
m) ütőhangszereken
n) orgonán
o) hárfán
p) gitáron
q) népi hangszeren
r) énekelni tanulok
s) nem tanulok

11. Családodban van-e hivatásos zenész? *(egy válasz jelölhető)*
a) van
b) nincs

12. **Milyen típusú együttesben, vagy zenekarban játszol, vagy énekelsz?** *(egy válasz jelölhető)*
a) szimfonikus zenekarban
b) fúvószenekarban
c) népzenei együttesben
d) énekkarban
e) könnyűzenei együttesben
f) vonószenekarban
g) kamaracsoportban
h) egyikben sem

13. Szoktál-e egyénileg hangversenyen szerepelni? *(egy válasz jelölhető)*
a) nem
b) néha
c) gyakran
d) rendszeresen

14. Szoktál-e énekkarral szerepelni? *(egy válasz jelölhető)*
a) nem
b) néha
c) gyakran
d) rendszeresen

15. Szoktál-e zenekarral fellépni? *(egy válasz jelölhető)*
a) nem
b) néha
c) gyakran
d) rendszeresen

16. Mennyire szeretsz fellépni szólistaként? *(egy válasz jelölhető)*

a) nagyon szeretek
b) szeretek
c) közömbös nekem
d) nem szeretek
e) nagyon nem szeretek
f) nem szoktam fellépni

17. Mennyire szeretsz fellépni énekkarral? *(egy válasz jelölhető)*

a) nagyon szeretek
b) szeretek
c) közömbös nekem
d) nem szeretek
e) nagyon nem szeretek
f) nem szoktam fellépni

18. Mennyire szeretsz fellépni zenekarral? *(egy válasz jelölhető)*

a) nagyon szeretek
b) szeretek
c) közömbös nekem
d) nem szeretek
e) nagyon nem szeretek
f) nem szoktam fellépni

19. Mennyire szeretsz énekelni? *(egy válasz jelölhető)*

a) nagyon szeretek
b) szeretek
c) közömbös nekem
d) nem szeretek
e) nagyon nem szeretek

20. Mennyire szereted az alábbi tantárgyakat? Minden tantárgy esetén jelöld a téged leginkább jellemző választ! *(soronként egy válasz jelölhető)*

	Egyáltalán nem szeretem	Nem szeretem	Közömbös	Szeretem	Nagyon szeretem	Nem tanulom
Matematika	○	○	○	○	○	○
Irodalom	○	○	○	○	○	○
Nyelvtan	○	○	○	○	○	○
Angol nyelv	○	○	○	○	○	○
Német nyelv	○	○	○	○	○	○
Francia nyelv	○	○	○	○	○	○
Történelem	○	○	○	○	○	○
Rajz	○	○	○	○	○	○
Fizika	○	○	○	○	○	○
Kémia	○	○	○	○	○	○
Testnevelés	○	○	○	○	○	○
Biológia	○	○	○	○	○	○
Informatika	○	○	○	○	○	○
Ének-zene	○	○	○	○	○	○
Szolfézs	○	○	○	○	○	○
Hangszeres óra (főtárgy)	○	○	○	○	○	○
Zenetörténet	○	○	○	○	○	○
Zenekar	○	○	○	○	○	○
Énekkar	○	○	○	○	○	○
Kamarazene	○	○	○	○	○	○

21. Ha tanulsz szolfézst, mennyire kedveled a szolfézs órák részterületeit? Jelöld a téged leginkább jellemző választ! *(soronként egy válasz jelölhető)*

	Egyáltalán nem szeretem	Nem szeretem	Közömbös	Szeretem	Nagyon szeretem
kottaolvasás	○	○	○	○	○
dallamírás	○	○	○	○	○
zenehallgatás	○	○	○	○	○
új dal tanulása	○	○	○	○	○
népdaléneklés	○	○	○	○	○
műdaléneklés	○	○	○	○	○
ritmusolvasás	○	○	○	○	○
hallásgyakorlatok	○	○	○	○	○
zenetörténet	○	○	○	○	○
formatan	○	○	○	○	○

22. Mennyire kedveled az ének-zene órák részterületeit? Jelöld a téged leginkább jellemző választ! *(soronként egy válasz jelölhető)*

	Egyáltalán nem szeretem	Nem szeretem	Közömbös	Szeretem	Nagyon szeretem
dalok éneklése	○	○	○	○	○
népdalelemzés	○	○	○	○	○
zenei ismeretek bővítése (új fogalmak)	○	○	○	○	○
egy zeneszerző életének áttekintése	○	○	○	○	○
új dal tanulása	○	○	○	○	○
zenehallgatás	○	○	○	○	○
ritmusgyakorlatok	○	○	○	○	○
kottaolvasás	○	○	○	○	○
kottaírás	○	○	○	○	○
hangszerek megismerése	○	○	○	○	○

23. Véleményed szerint mennyire igaz rád az állítás? Jelöld a téged leginkább jellemzőt!
(soronként egy válasz jelölhető)

	1	2	3	4	5
Kottakép alapján felismerem az alapvető zenei szimbólumokat: hangjegyeket, ritmusértékeket.	○	○	○	○	○
Gyorsan tudok kottát olvasni.	○	○	○	○	○
Gyakran elakadok kottaolvasás közben.	○	○	○	○	○
A kottaolvasás sebességét aszerint változtatom, hogy milyen nehézségű zenei anyagot olvasok.	○	○	○	○	○
Lassan, de gondosan olvasom a kottát.	○	○	○	○	○
Kottaolvasás közben tudok hosszú távon koncentrálni.	○	○	○	○	○
A ritmust könnyebben tudom olvasni, mint a dallamot.	○	○	○	○	○
Jó kottaolvasónak tartom magam.	○	○	○	○	○
Számomra fontos, hogy jó kottaolvasóvá váljak.	○	○	○	○	○

24. Mi volt a legutóbbi tanulmányi eredményed az alábbi tantárgyakból?
(soronként egy válasz jelölhető)

	1	2	3	4	5	Nem tanulom
Matematika	○	○	○	○	○	○
Irodalom	○	○	○	○	○	○
Nyelvtan	○	○	○	○	○	○
Angol nyelv	○	○	○	○	○	○
Német nyelv	○	○	○	○	○	○
Francia nyelv	○	○	○	○	○	○
Történelem	○	○	○	○	○	○
Rajz	○	○	○	○	○	○
Fizika	○	○	○	○	○	○
Kémia	○	○	○	○	○	○
Testnevelés	○	○	○	○	○	○
Biológia	○	○	○	○	○	○
Informatika	○	○	○	○	○	○
Ének-zene	○	○	○	○	○	○
Szolfézs	○	○	○	○	○	○
Hangszeres óra (főtárgy)	○	○	○	○	○	○
Zenetörténet	○	○	○	○	○	○
Zenekar	○	○	○	○	○	○
Énekkar	○	○	○	○	○	○
Kamarazene	○	○	○	○	○	○

25. Van-e otthon számítógép (laptop)? *(soronként egy válasz jelölhető)*

a) igen
b) nem

26. Van-e otthon internet? *(soronként egy válasz jelölhető)*

a) igen
b) nem

27. Milyen gyakran internetezel? Jelöld a megfelelő választ! *(soronként egy válasz jelölhető)*
a) hetente 1-2 órát b) hetente 3-6 órát c) naponta 1-2 órát d) naponta 3-4 órát e) naponta 4 óránál többet

28. Milyen idegen nyelveket tanulsz? *(soronként egy válasz jelölhető)*
Első idegen nyelvként: a) angol b) német c) francia d) egyéb e) nem tanulok
Második idegen nyelvként a) angol b) német c) francia d) egyéb e) nem tanulok idegen nyelvet

29. Mennyire szeretsz iskolába járni? Jelöld a téged leginkább jellemző választ! *(egy válasz jelölhető)*

a) nagyon szeretek
b) szeretek
c) közömbös nekem
d) nem szeretek
e) nagyon nem szeretek

30. Mennyire vagy elégedett a mostani iskolai teljesítményeiddel? Jelöld a téged leginkább jellemző választ!
(egy válasz jelölhető)

a) Nagyon elégedetlen
b) Elégedetlen
c) Közepesen elégedett
d) Elégedett
e) Nagyon elégedett

31. Mi az a legmagasabb iskolai végzettség, amelyet szeretnél elérni? Jelölj meg egyet! *(egy válasz jelölhető)*

a) abbahagyni az iskolát, amilyen hamar lehet
b) elvégezni a nyolc általánost
c) szakmunkás végzettséget szerezni
d) érettségizni
e) érettségi után szakképzettséget (technikusi vagy OKJ felsőfokú képzettséget) szerezni
f) diplomát szerezni felsőfokú alapképzésben (korábban főiskola)
g) diplomát szerezni felsőfokú mesterképzésen (korábban egyetem)
h) Doktori (PhD) fokozatot szerezni
i) még nem tudom

32. Tervezel-e zenei pályát? *(egy válasz jelölhető)*
a) igen
b) nem

33. Hány lakószoba van a lakásotokban? (Nem számít lakószobának: konyha, fürdőszoba, kamra, WC, folyosó, tároló, pince, műhely.) *(egy válasz jelölhető)*
a) 1
b) 2
c) 3
d) 4
e) 5
f) több

34. Hány darab van a családodban a következő tárgyakból? Jelöld minden tárgy esetén a megfelelő számot! (soronként egy válasz jelölhető)

	egy sincs	egy	kettő	három vagy több
mobiltelefon	○	○	○	○
számítógép/laptop	○	○	○	○
tablet	○	○	○	○
televízió	○	○	○	○
személygépkocsi	○	○	○	○

35. Hány könyvetek van otthon összesen? A tankönyveidet, az újságokat és a folyóiratokat ne számold bele! Jelöld a megfelelő választ! *(egy válasz jelölhető)*
a) kevesebb, mint egypolcnyi (körülbelül 0–50 db)
b) egypolcnyi (körülbelül 50 db)
c) 2-3 könyvespolcnyi (maximum 150 db)
d) 4-6 könyvespolcnyi (maximum 300 db)
e) 2 könyvszekrényre való (300–600 db)
f) 3 vagy több könyvszekrényre való (600–1000 db) g) 1000 darabnál több könyv 31.

36. Mennyire szeretsz olvasni? Jelöld a téged leginkább jellemző választ! *(egy válasz jelölhető)*
a) nagyon szeretek
b) szeretek
c) közömbös nekem
d) nem szeretek
e) nagyon nem szeretek

Appendix D Survey guidlines of the music reading test

MUSIC READING SKILLS

Survey guidelines

What does the test measure?

The aim of our research is to investigate the results of tasks which can help us to get an overall picture of our students' music reading skills during online testing.

In the online survey students are supposed to do tasks related to music reading. Students do not have to prepare for the test. The exercises can be done in any order, and corrections can be made any time before the end of the test. Students are not allowed to be given any information about the tasks prior to testing and no outside aids can be used.

Pupils have 55-60 minutes to finish their work, but please allow those students who need more time to complete it as well.

After the test students are asked to fill in a background questionnaire so that the relationship between music reading skills and other background variables can be explored. It takes 15 minutes to fill in the questionnaire, which can be found right after the tasks. If the students are not sure how to answer a question, please help them.

Where is the test available?

The test is available on the following website: edia.hu/music1

What preparations are needed before testing?

Before administering the task, please

- arrange the classroom, turn on the computers, then start with the tasks and go on to the questionnaire.
- have the students' survey identity number at hand and give it to them before they enter the classroom;
- make sure that the students put the right survey identity number in the identity field on the screen. If this is missing, the students' surveys cannot be accessed by others;
- provide students with earphones as necessary.

Before testing we ask you to:

- Please, prepare the room for the testing; turn on the computers, launch a web browser (Mozilla Firefox or Google Chrome - other browsers cannot be used). It is important that computers have the latest versions of browsers. Recently, a number of improvements implemented in the system, it is essential to update the browser for the undisturbed running of the tests. Due to earlier versions may fail the test!
- Please, load the test in each machine and start it!

- Please help to prepare on time students' identity numbers, and after their arrival ask them to type their code properly!
- The identity numbers of the missing students' cannot be used by the others.

Before the students start the tasks, please draw their attention to the following four points:

1. In the test there are 55 tasks altogether which can be done in any order.

2. They can use the arrows in the left and right bottom corner to move between the tasks and they can make corrections at any time before the end of the test.

3. After completing the last task, no modifications are possible.

4. After the last exercise they can find further questions.

What should we focus during testing?

Please, write down the students' comments during the process of the measurement, and help our work with your suggestions.

Please, note that...

- what kind of questions ask the students related to the tasks
- what other comments and suggestions could you formulate about the tasks and data recording?
- Should you have any comments or suggestions, do not hesitate to contact me.

If you are interested in the eDia project, please visit our website and choose the English language: edia.hu

Thank you, in advance, for your help and support in conducting our survey.

Appendix E The descriptive statistics of the music reading tasks (Study 4)

Table 73 The descriptive statistics of the music reading tasks (Study 4)

Task	*Mean (%)*	*SD (%)*	*Item-total correlation*	*Item-deleted reliability*
t19	98	14.8	0.289	0.857
t18	98	14.8	0.203	0.857
t06	94	23.0	0.198	0.858
t21	92	26.9	0.185	0.857
t20	92	26.9	0.170	0.858
t54	88	32.9	0.494	0.853
t16	88	32.9	0.319	0.855
t46	87	34.2	0.408	0.854
t15	83	37.5	0.319	0.855
t45	82	38.4	0.424	0.854
t11	82	38.4	0.318	0.855
t35	81	39.4	0.187	0.857
t14	80	40.2	0.467	0.853
t34	79	41.0	0.320	0.855
t09	79	41.0	0.278	0.856
t23	77	42.5	0.344	0.855
t12	77	42.5	0.246	0.857
t53	77	42.5	0.219	0.857
t27	76	43.2	0.326	0.855
t10	76	43.2	0.236	0.857
t01	76	43.2	0.420	0.853
t22	74	43.9	0.276	0.856
t42	73	44.5	0.299	0.856
t03	72	45.0	0.299	0.856
t52	71	45.6	0.268	0.856
t41	70	46.1	0.253	0.856
t05	70	46.1	0.197	0.858
t24	69	46.6	0.160	0.858
t28	67	47.4	0.194	0.858
t02	67	47.4	0.274	0.856
t32	66	47.8	0.340	0.855
t07	63	48.5	0.188	0.858
t43	62	48.8	0.218	0.857
t55	61	49.0	0.612	0.849
t13	60	49.3	0.210	0.857
t08	57	49.8	0.198	0.858
t25	56	50.0	0.373	0.854
t49	54	50.1	0.412	0.853
t31	54	50.1	0.339	0.855
t29	49	50.3	0.444	0.853
t36	48	50.2	0.112	0.859
t48	44	50.0	0.510	0.851
t38	44	50.0	0.214	0.857
t50	44	50.0	0.426	0.853
t47	41	49.5	0.203	0.858
t51	39	49.0	0.257	0.856
t33	37	48.5	0.254	0.857
t04	36	48.1	0.232	0.857
t26	34	47.8	0.425	0.853
t44	30	46.1	0.315	0.855
t40	30	46.1	0.318	0.855
t37	29	45.6	0.249	0.857
t39	22	41.8	0.390	0.854
t30	17	37.5	0.422	0.854

Appendix F The descriptive statistics of the music reading tasks (Study 5)

Table 74 The descriptive statistics of music reading test in music school (%p) (Study 5)

Task	*Mean*	*SD*
t18	100	0.00
t19	97	15.7
t27	97	17.5
t20	97	17.5
t46	95	21.9
t21	95	21.9
t06	95	21.9
t53	92	27.4
t15	92	27.4
t16	91	28.3
t45	89	30.9
t23	89	31.7
t12	89	31.7
t05	88	32.5
t54	88	32.5
t14	88	33.2
t22	87	33.2
t01	87	33.9
t42	86	34.5
t55	86	34.5
t11	86	34.5
t52	85	35.8
t34	84	37.0
t02	83	37.6
t35	83	37.6
t24	82	38.6
t03	82	38.6
t31	81	39.6
t51	81	3.96
t10	80	40.1
t09	79	41.0
t25	79	41.0
t13	78	41.5
t07	77	42.3
t29	76	43.1
t43	75	43.4
t41	71	45.7
t50	70	46.0
t08	69	46.2
t49	69	46.5
t28	68	46.7
t26	66	47.4
t32	66	47.4
t48	59	49.3
t33	53	50.1
t47	51	50.1
t40	49	50.2
t37	48	50.1
t36	46	50.0
t38	46	50.0
t39	42	49.6
t30	42	49.5
t04	36	48.0

Appendix G Differences between the achievements of the school types (Study 7)

Table 75 Differences between the achievements of the school types (Study 7)

Common tasks	*Music school* *M (SD)*	*Mainstream school* *M (SD)*	*t*	*p*
t01	86.88 (33.90)	52.92 (49.95)	10.23	<0.001
t02	83.88 (37.57)	42.77 (49.51)	11.37	<0.001
t03	81.88(38.64)	52.00 (49.99)	8.22	<0.001
t05	88.13 (32.45)	48.00 (50.01)	12.32	<0.001
t06	95.00 (21.86)	67.00 (47.19)	11.20	<0.001
t07	76.88 (42.29)	55.00 (49.77)	5.61	<0.001
t08	69.38 (46.23)	56.00 (49.67)	3.22	<0.001
t09	78.75 (41.03)	51.54 (50.01)	7.17	<0.001
t10	80.00 (40.12)	43.23 (49.57)	9.88	<0.001
t11	86.25 (34.54)	54.00 (49.87)	9.60	<0.001
t13	78.13 (41.47)	14.46 (35.19)	17.89	<0.001
t15	91.88 (27.40)	74.31 (43.72)	6.35	<0.001
t16	91.25 (28.34)	66.15 (47.35)	6.42	<0.001
t18	100.00 (0.00)	95.85 (19.96)	2.63	<0.001
t21	95.00 (21.86)	56.92 (49.55)	14.63	<0.001
t22	87.50 (33.17)	47.54 (49.97)	9.60	<0.001
t23	88.75 (31.69)	31.85 (46.62)	18.34	<0.001
t25	78.75 (41.03)	32.31 (46.80)	12.45	<0.001
t27	96.88 (17.45)	42.46 (49.46)	22.85	<0.001
t32	66.25 (47.43)	40.31 (49.08)	6.15	<0.001
t34	83.75 (37.00)	31.54 (46.50)	15.14	<0.001
t35	83.13 (37.57)	74.62 (43.55)	2.48	<0.001
t37	47.50 (50.00)	32.31 (46.80)	3.483	<0.001
t38	45.63 (49.96)	29.38 (45.58)	3.74	<0.001
t43	75.00 (43.43)	58.24 (49.35)	4.25	<0.001
t45	89.38 (30.91)	57.54 (49.46)	10.203	<0.001
t46	95.00 (21.86)	62.31 (48.49)	12.72	<0.001
t47	51.25 (50.14)	69.69 (45.99)	-4.235	<0.001
t49	68.75 (46.49)	40.22 (49.07)	6.876	<0.001
t50	70.00 (45.97)	38.83 (48.77)	7.32	<0.001
t52	85.00 (35.81)	81.38 (38.95)	1.12	<0.005
t53	91.88 (27.40)	68.41 (46.52)	8.28	<0.001
t54	88.13 (32.45)	80.89 (39.34)	2.41	<0.001
t55	86.25 (34.54)	34.10 (47.44)	15.77	<0.001